

Space Weather Models running in real-time or forecasting mode

Yihua Zheng

Space Weather Forecasting Training 2019

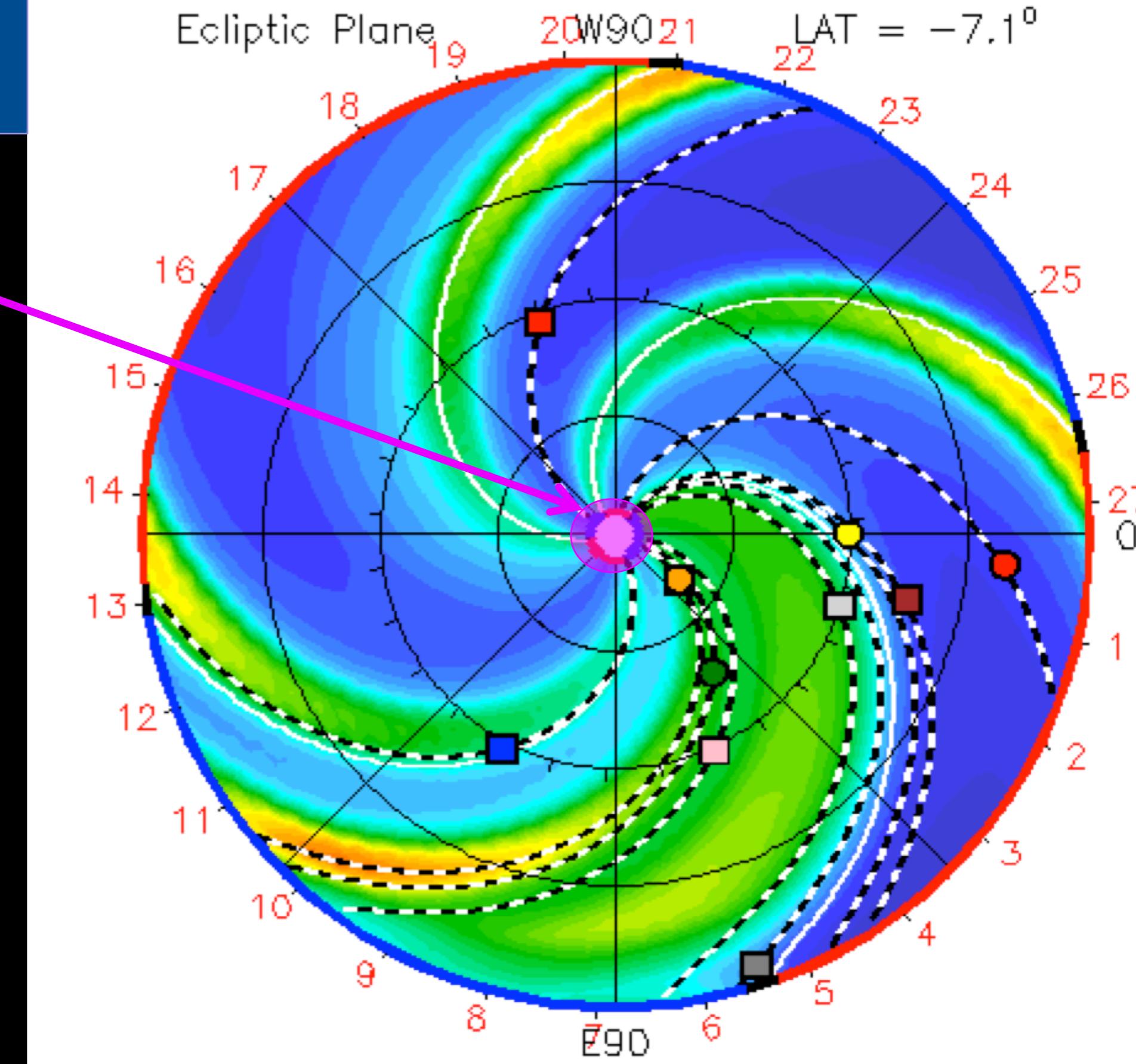
About WSA+ENLIL

The WSA+ENLIL Model Suite

Wang-Sheeley-Arge (WSA) Model)

Photospheric magnetic field maps (can be from satellite observations such as SOHO/MDI or SDO/HMI or ground-based observations such as the GONG magnetogram) are used as input to the WSA model (model solar corona up to 21.5 Rs) to represent the ambient solar wind.

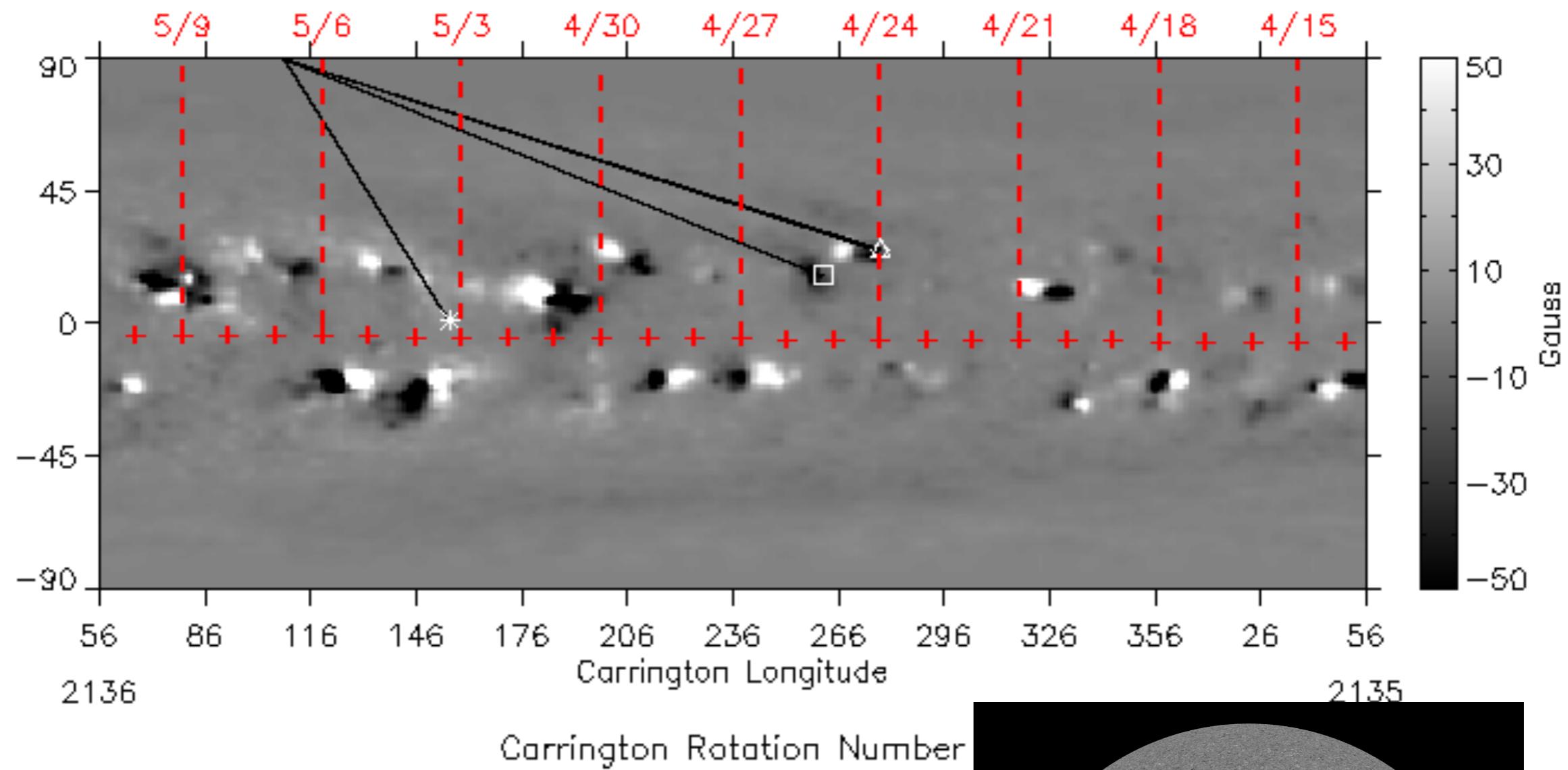
ENLIL: 0.1 AU – 2 AU (operations)



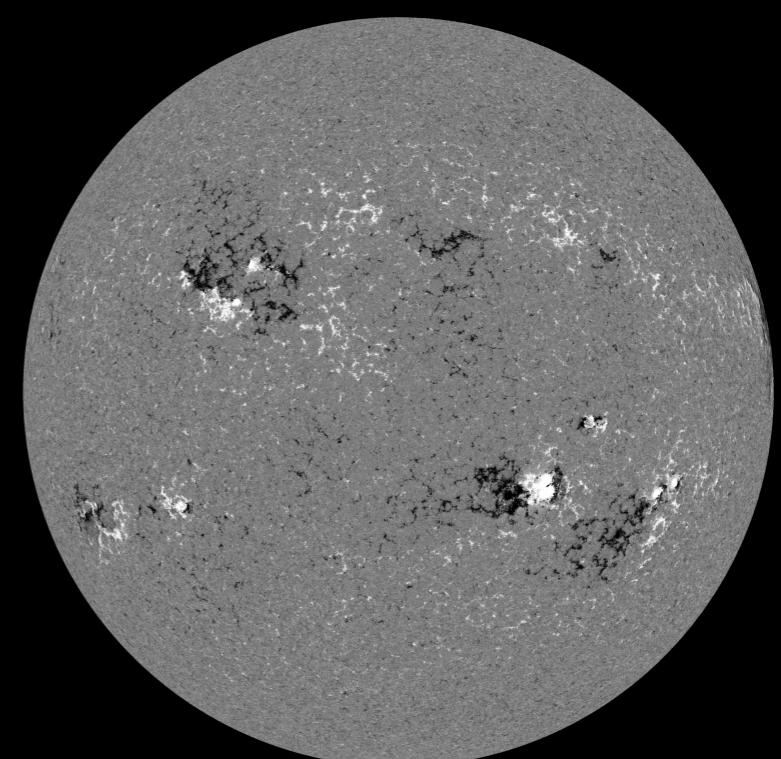
Model of the solar wind in the heliosphere

earth diamond
venus diamond
mercury square

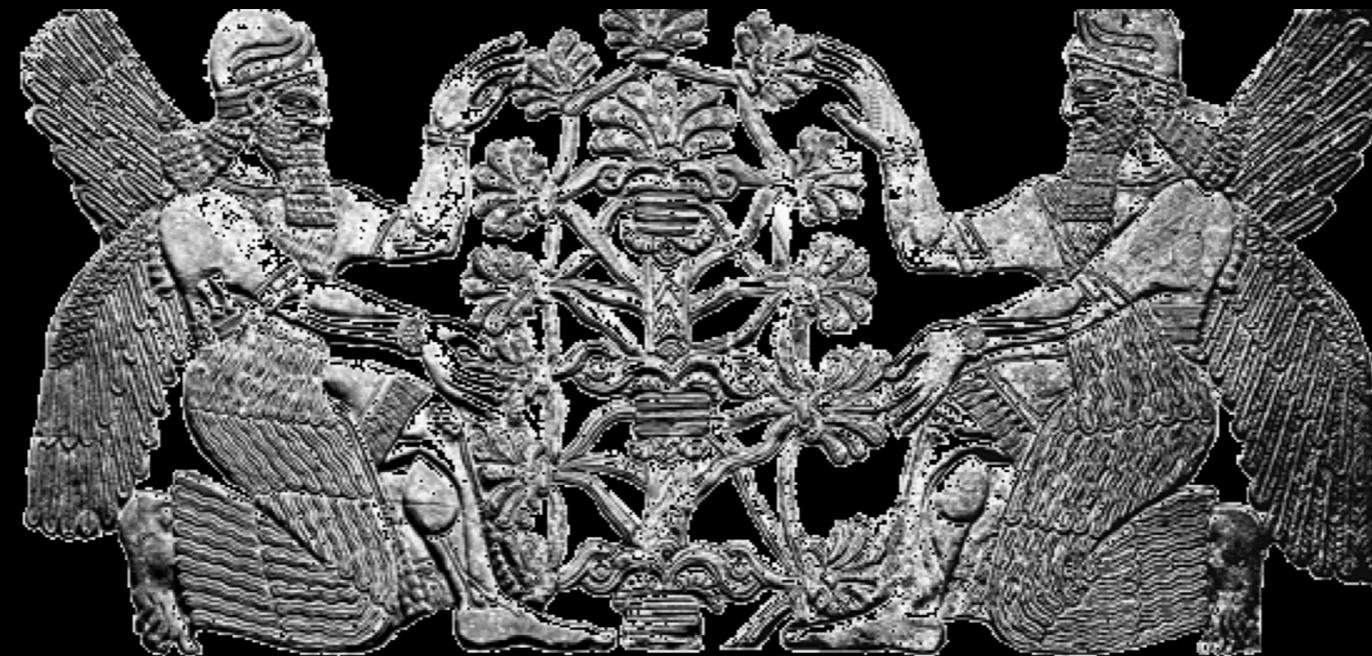
Observed Photospheric Field from GON



Inputs



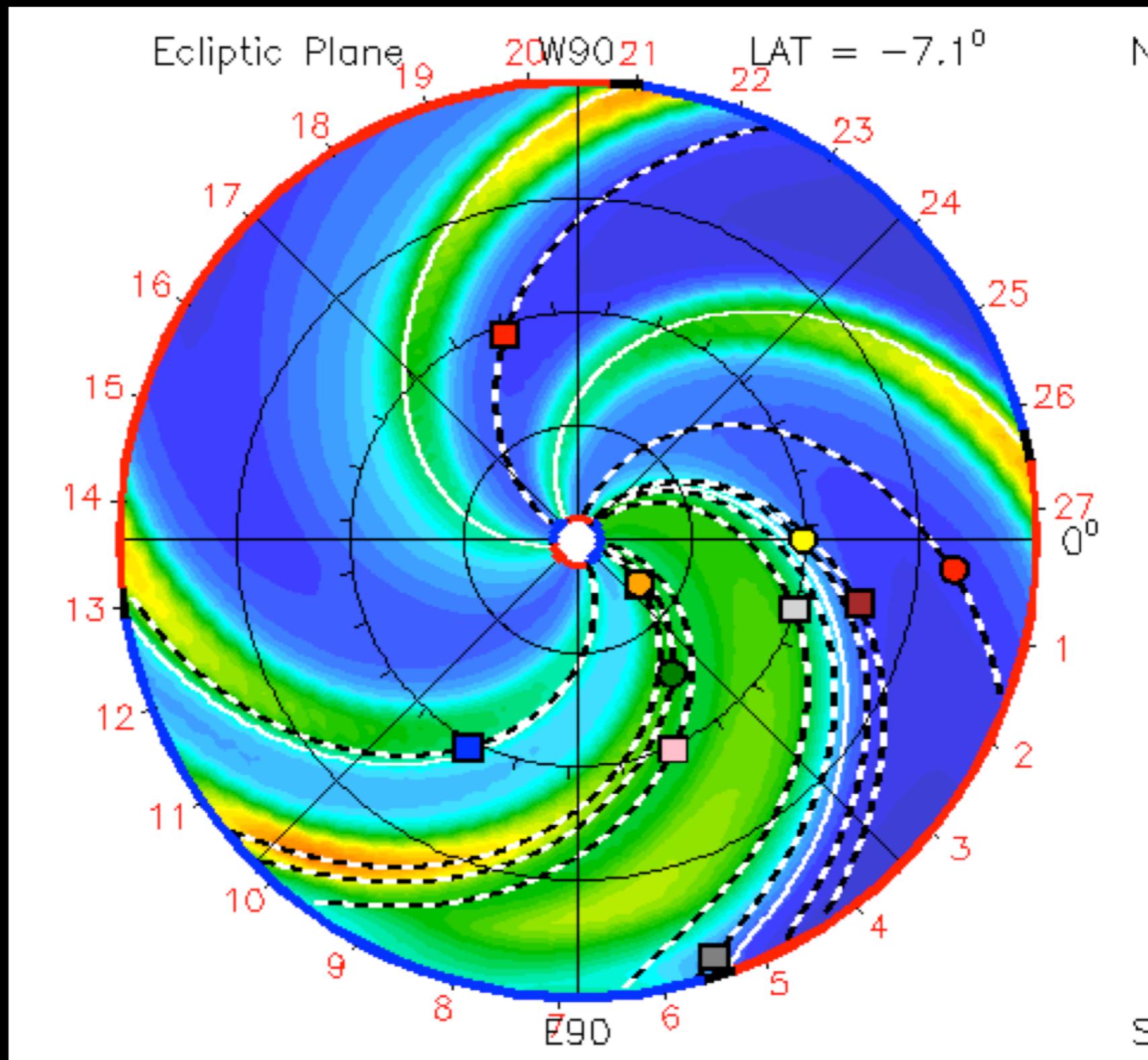
**EN = Lord + LÍL = Storm, "Lord (of
the) Storm"**



Courtesy: Dusan Odstrcil

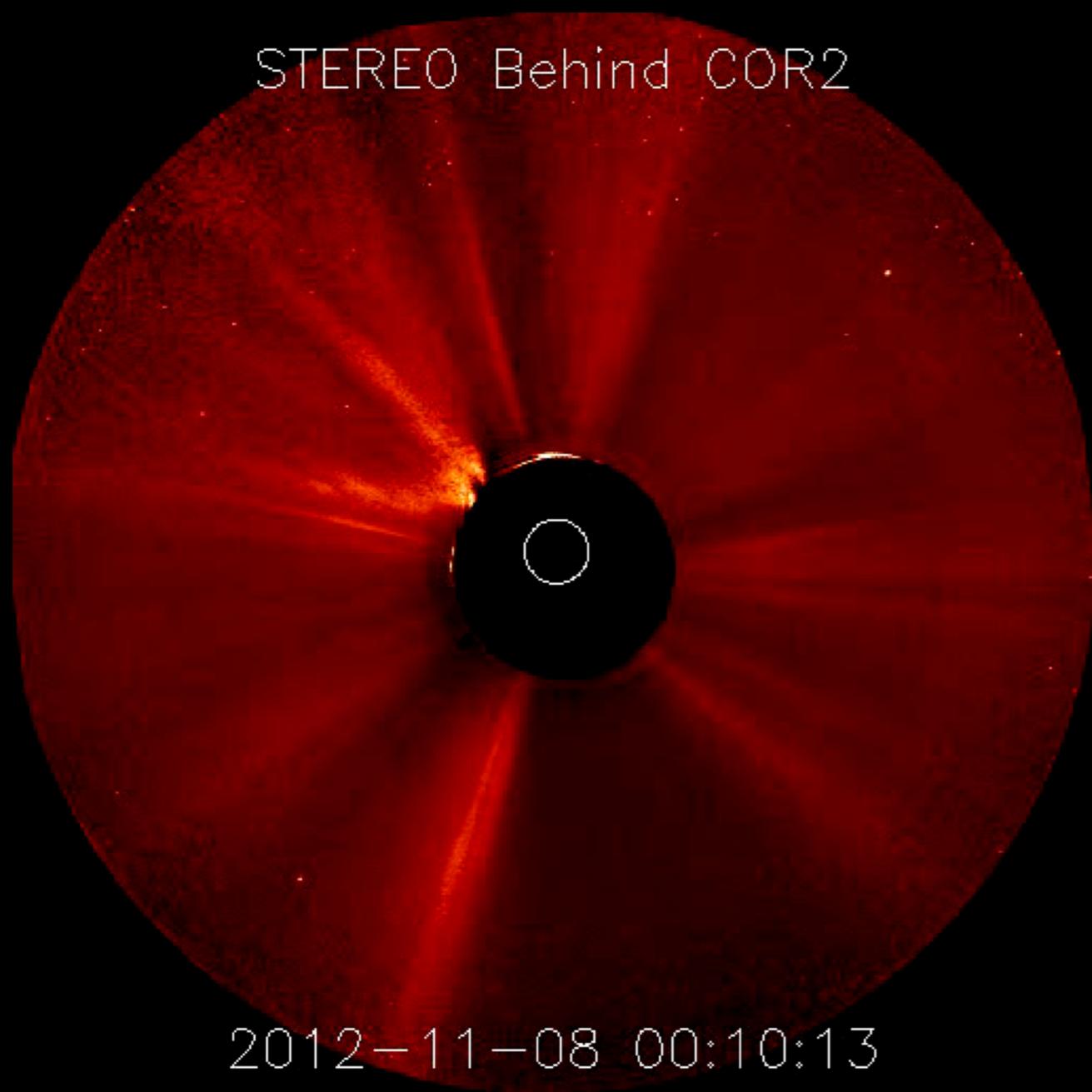
WSA+ENLIL:
capable of modeling the solar
wind for both ‘fair’ weather
and ‘storm’ conditions

Fair weather: ambient solar wind



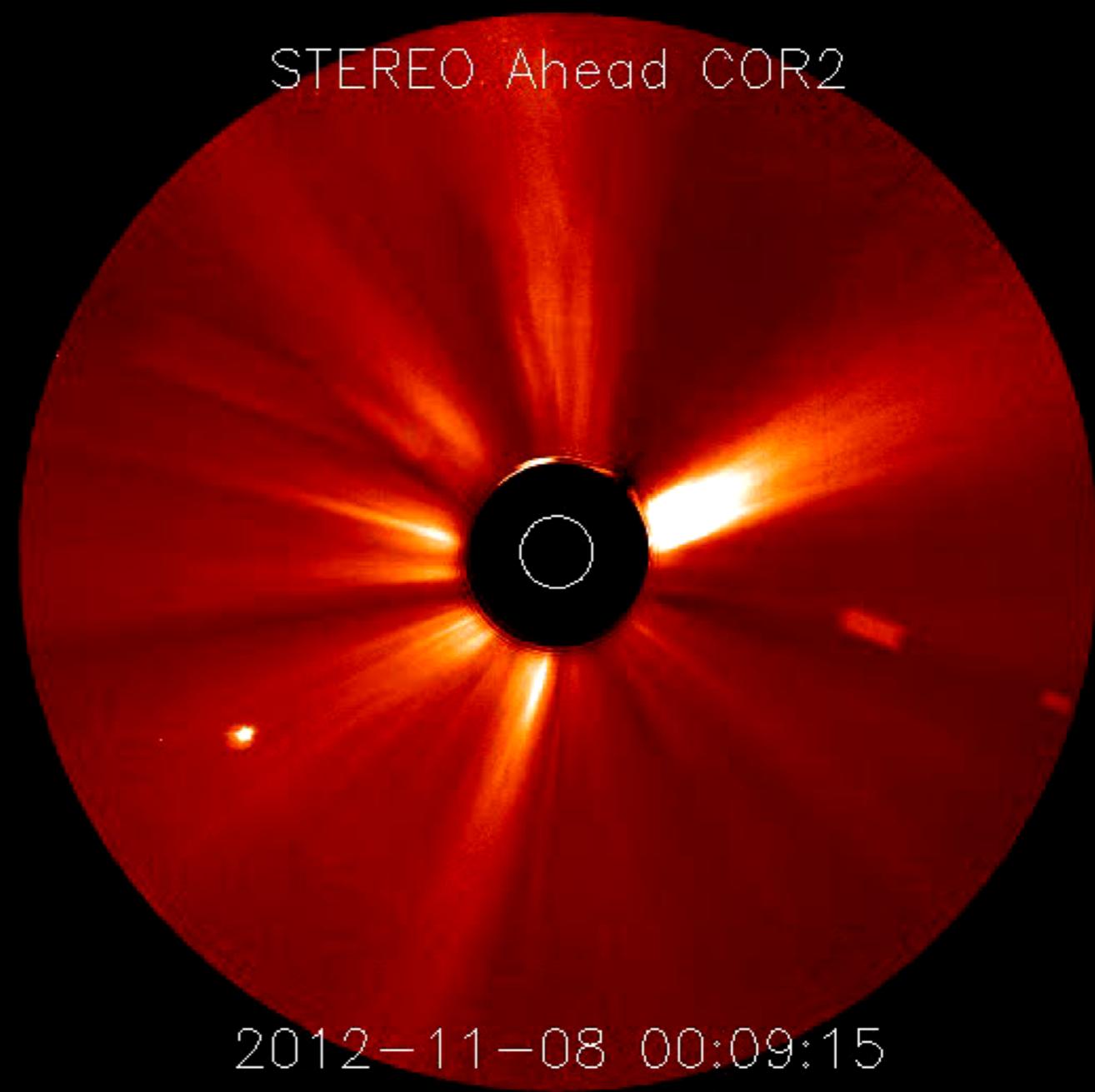
Stormy Weather: Eruptions (CME)

STEREO Behind COR2



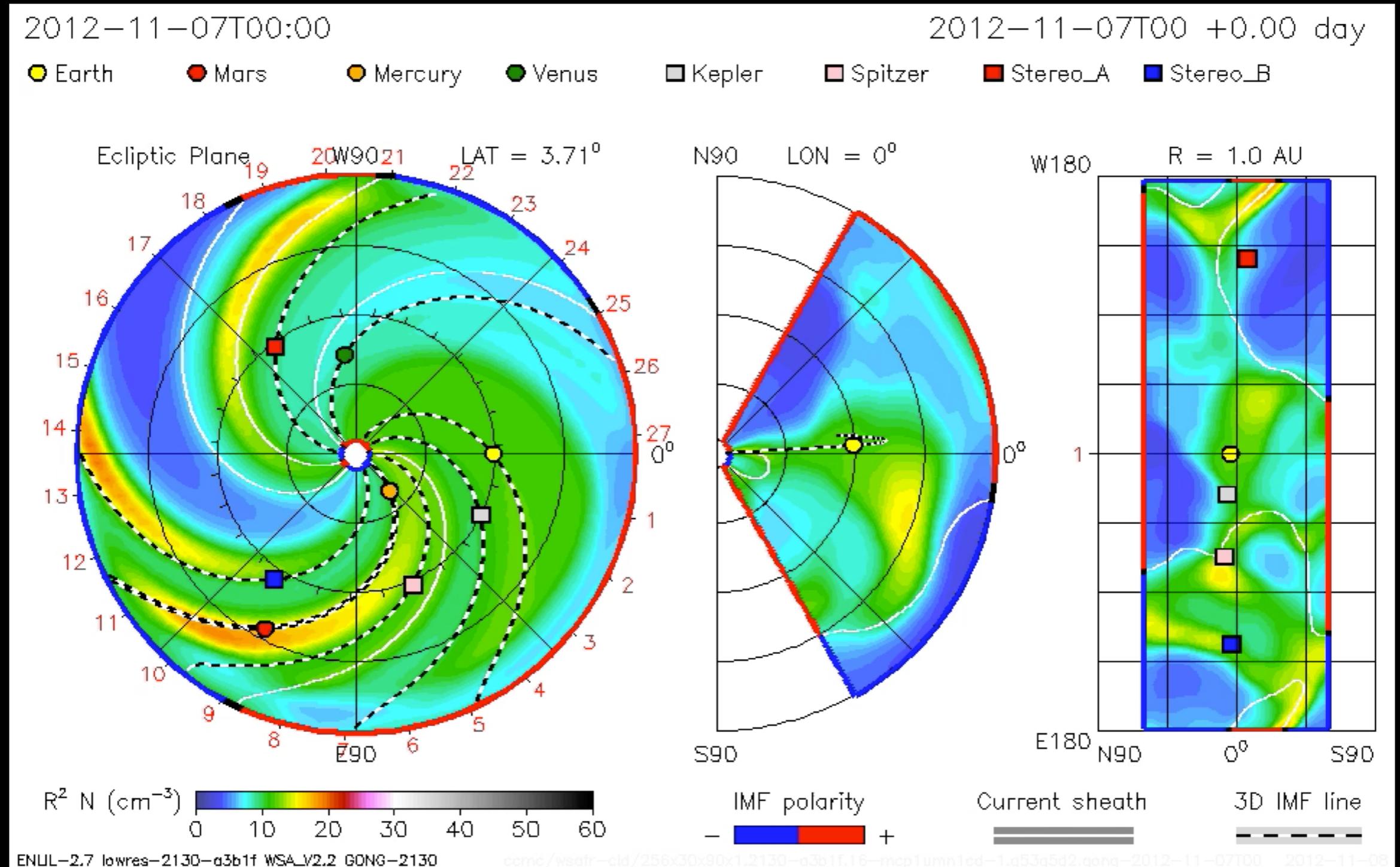
2012-11-08 00:10:13

STEREO Ahead COR2

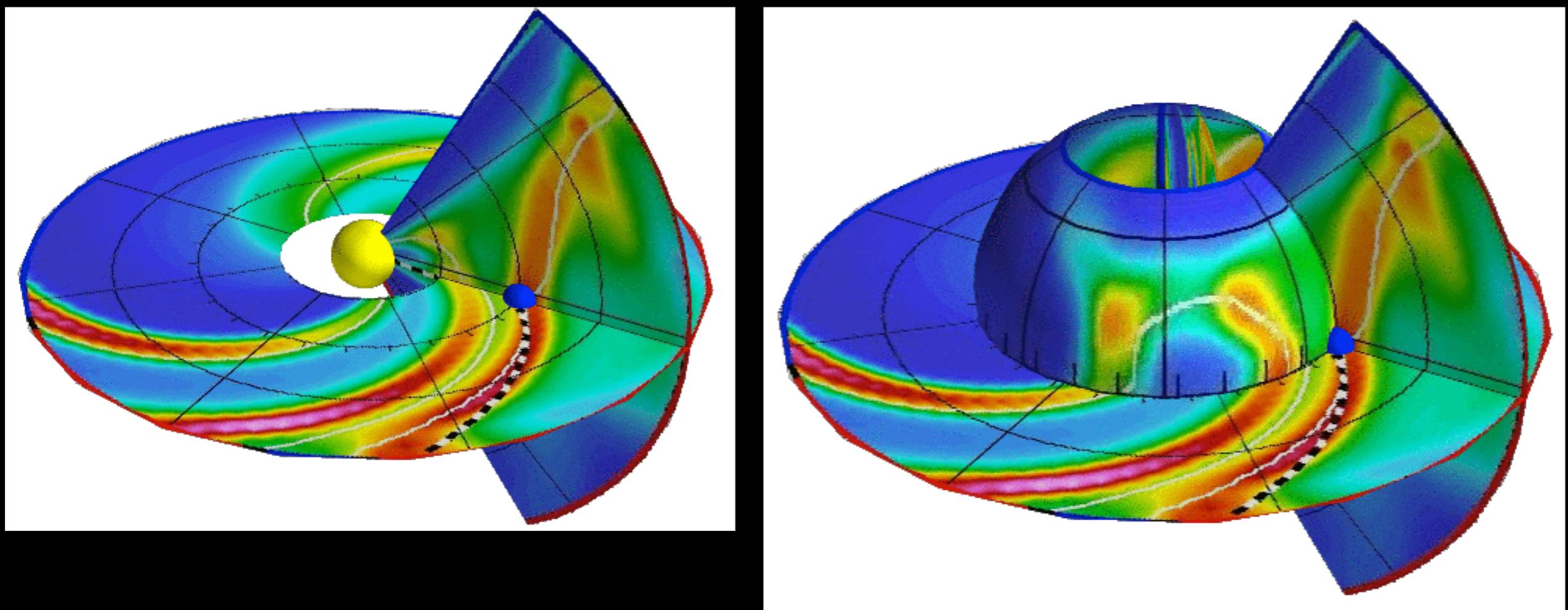


2012-11-08 00:09:15

Modeling of solar wind under stormy conditions



ENLIL Visualization



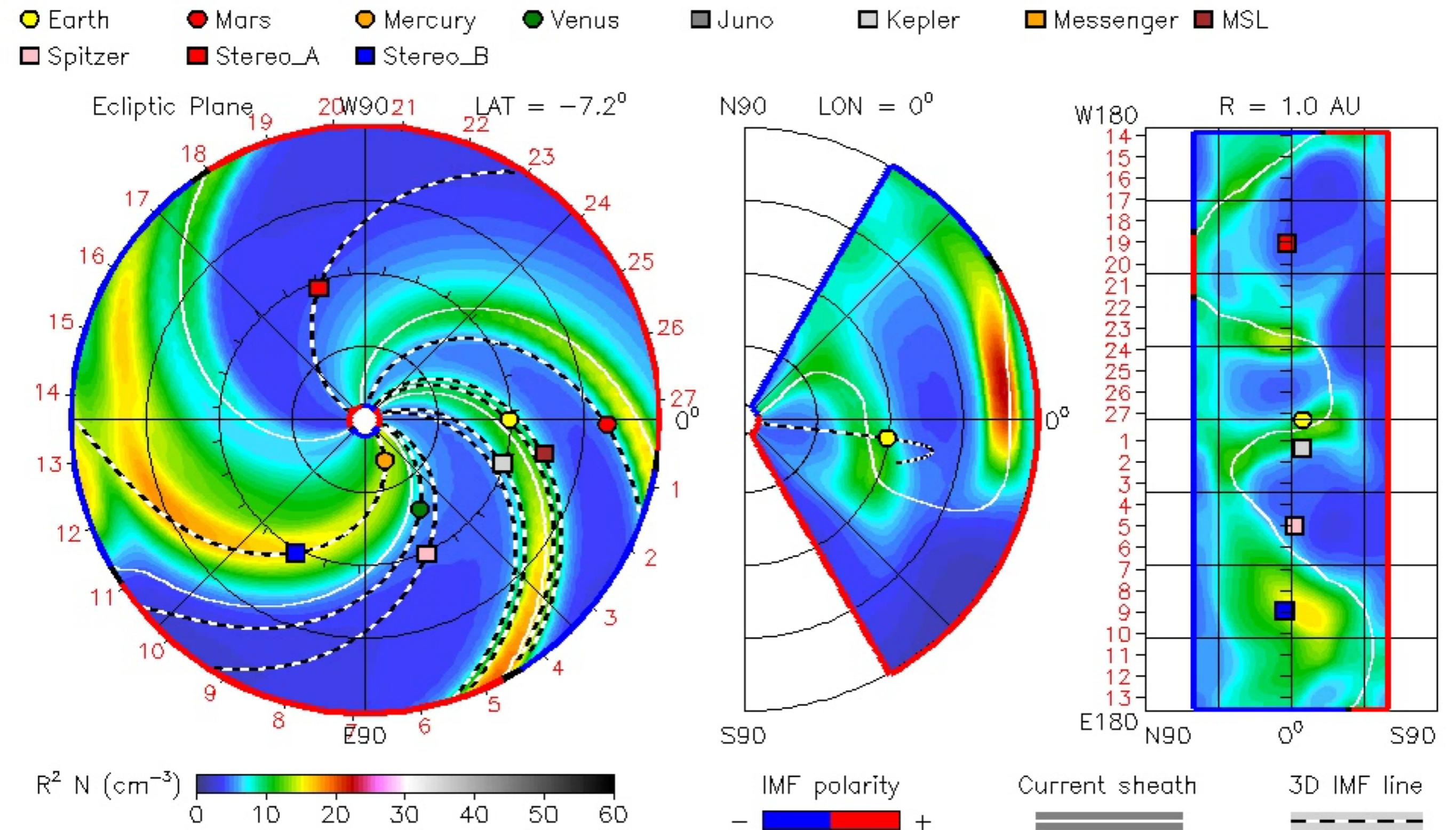
Courtesy of Stijn Calders @BIRA

Modeling of solar wind under stormy conditions

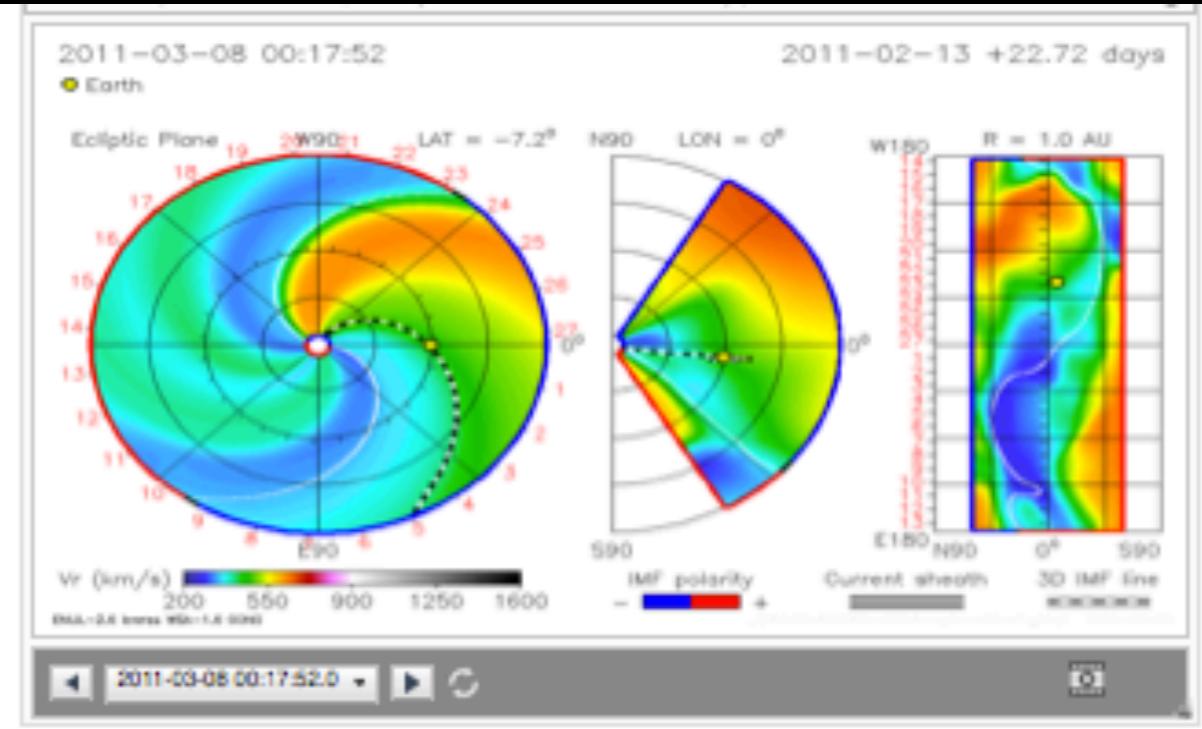
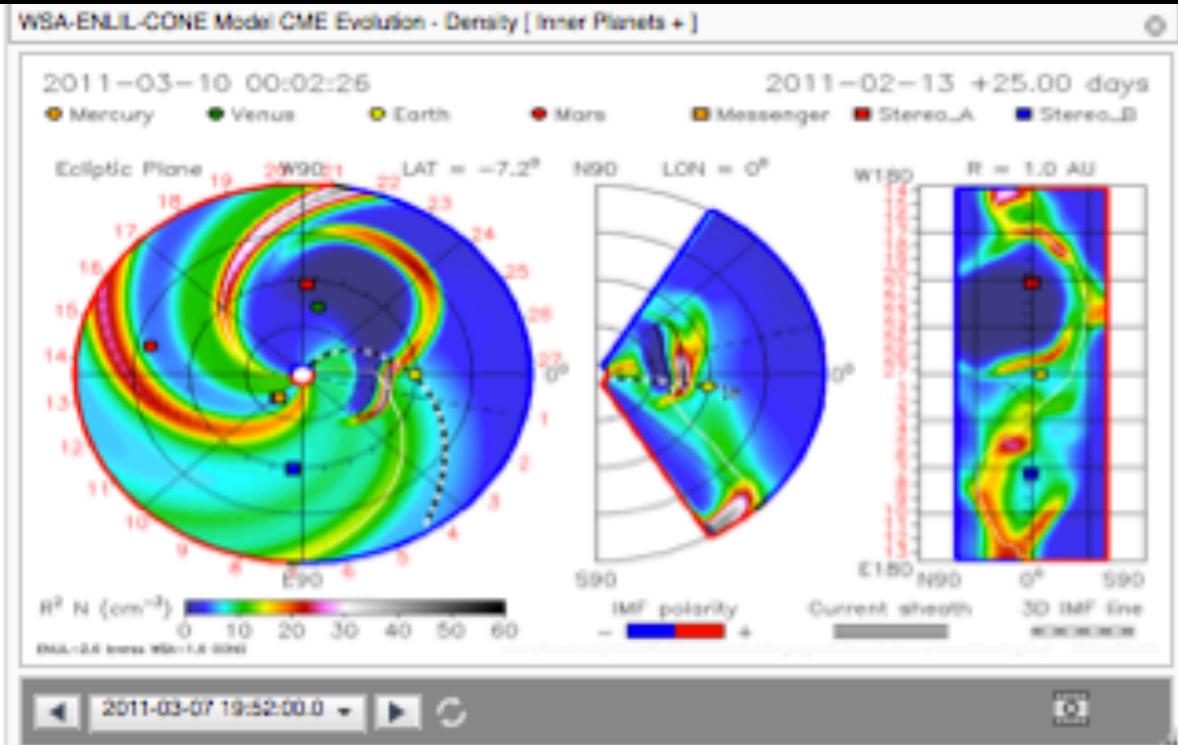
Earth-directed

2012-03-06T00:00

2012-03-06T00 +0.00 day



Forecasting capability enabled by WSA+ENLIL



WSA+ENLIL+cone

Predicting impacts of CMEs

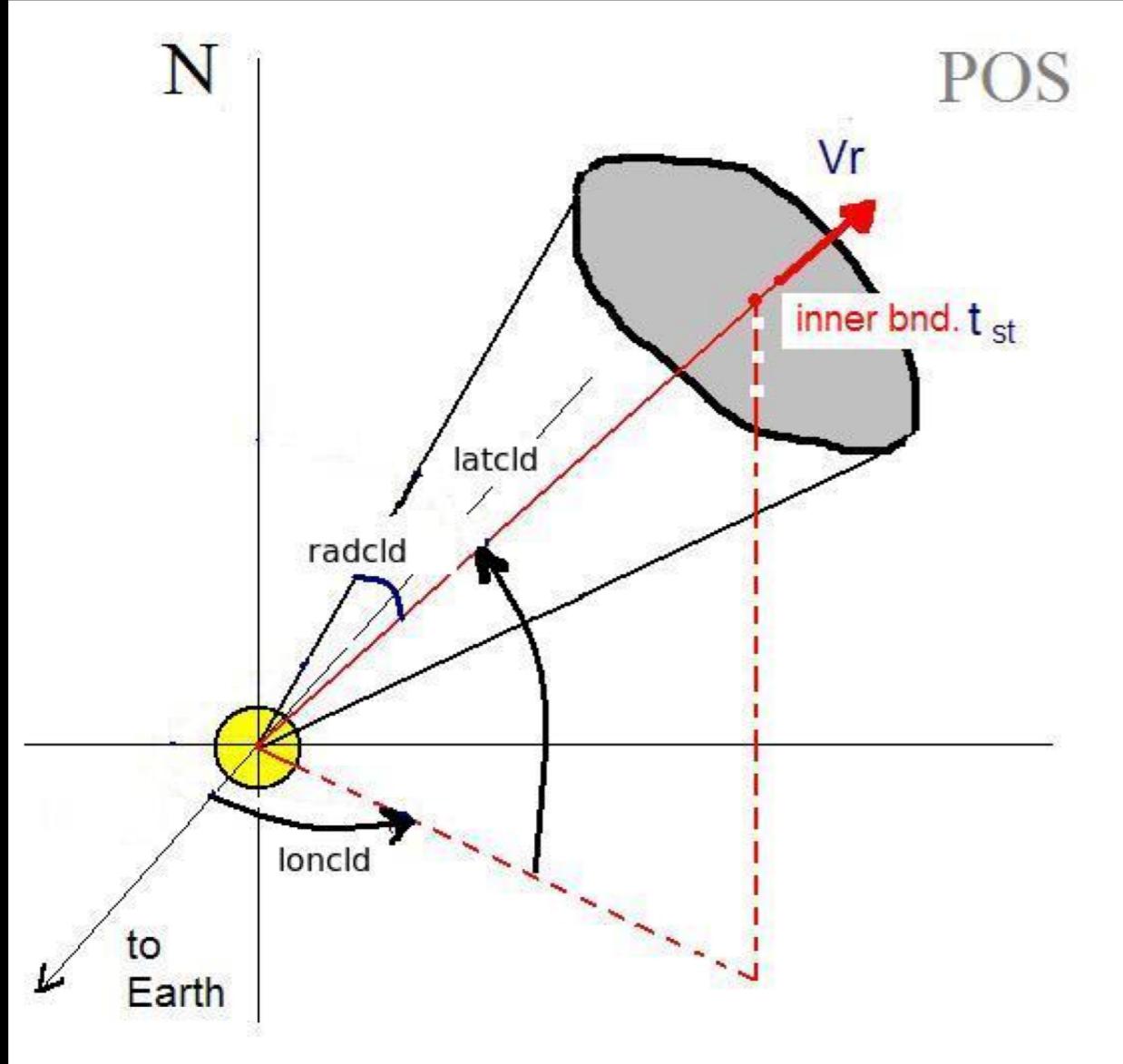
WSA+ENLIL

Modeling and predicting the
ambient solar wind

How to Model CMEs

- Cone Concept

Input to ENLIL cone model run



- Tstart - when cloud at 21.5Rs
- Latitude
- Longitude
- Radius (half angular width)
- V_r - radial velocity

Triangulation Tool

DEMO

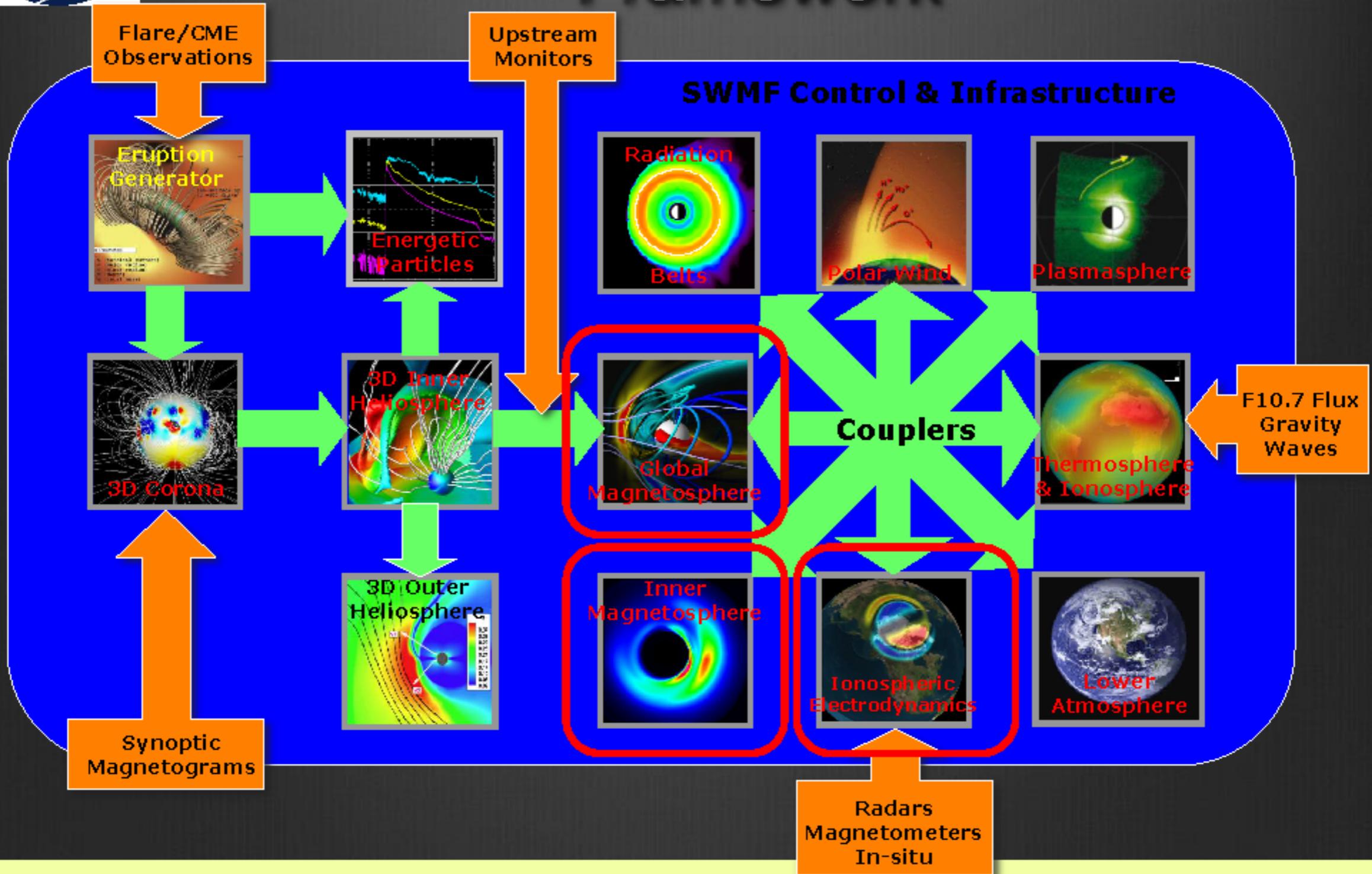
Start time of the event: 2013-04-
11T07:36Z.
t1: 08:00Z
t2: 10:30Z

Triangulation Tool

CME analysis tool - Antti

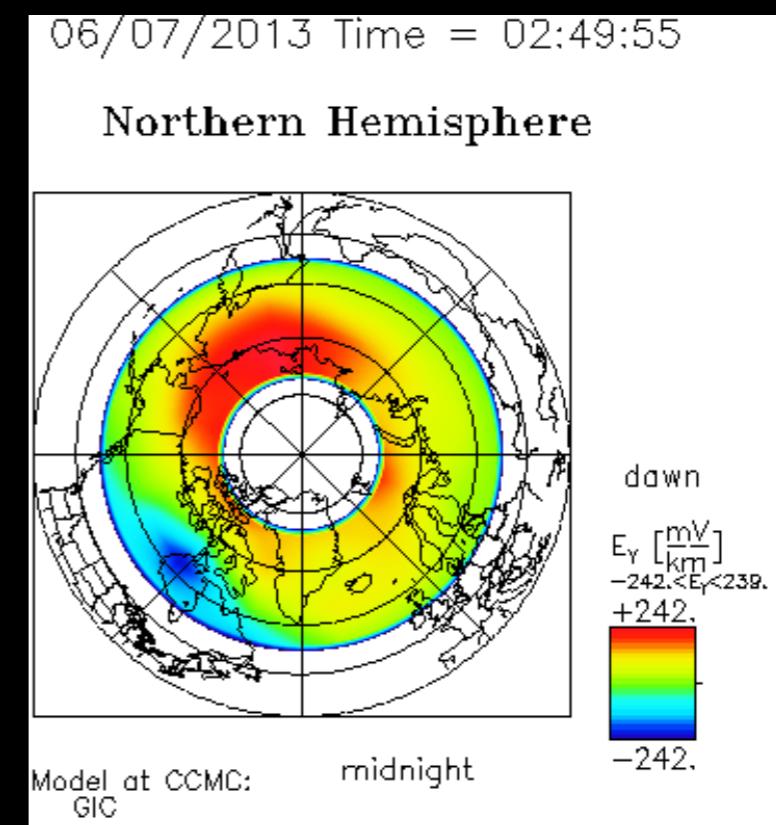
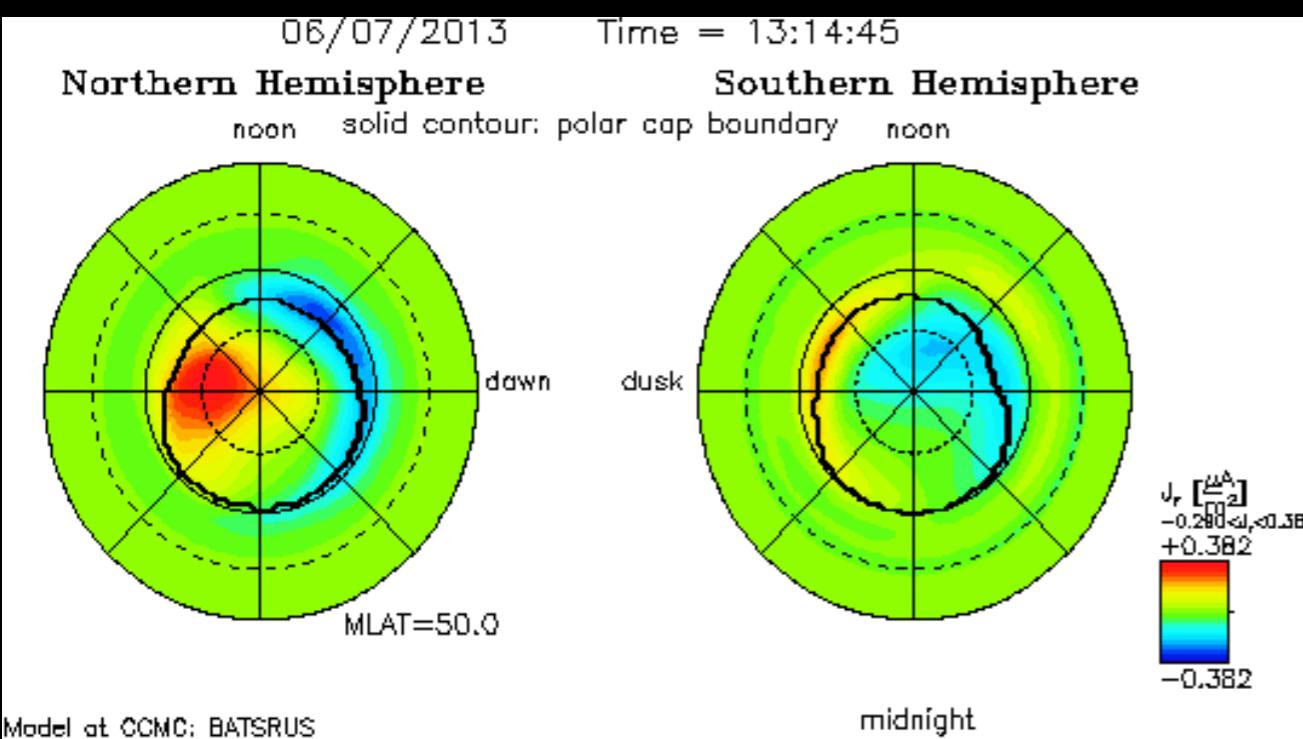
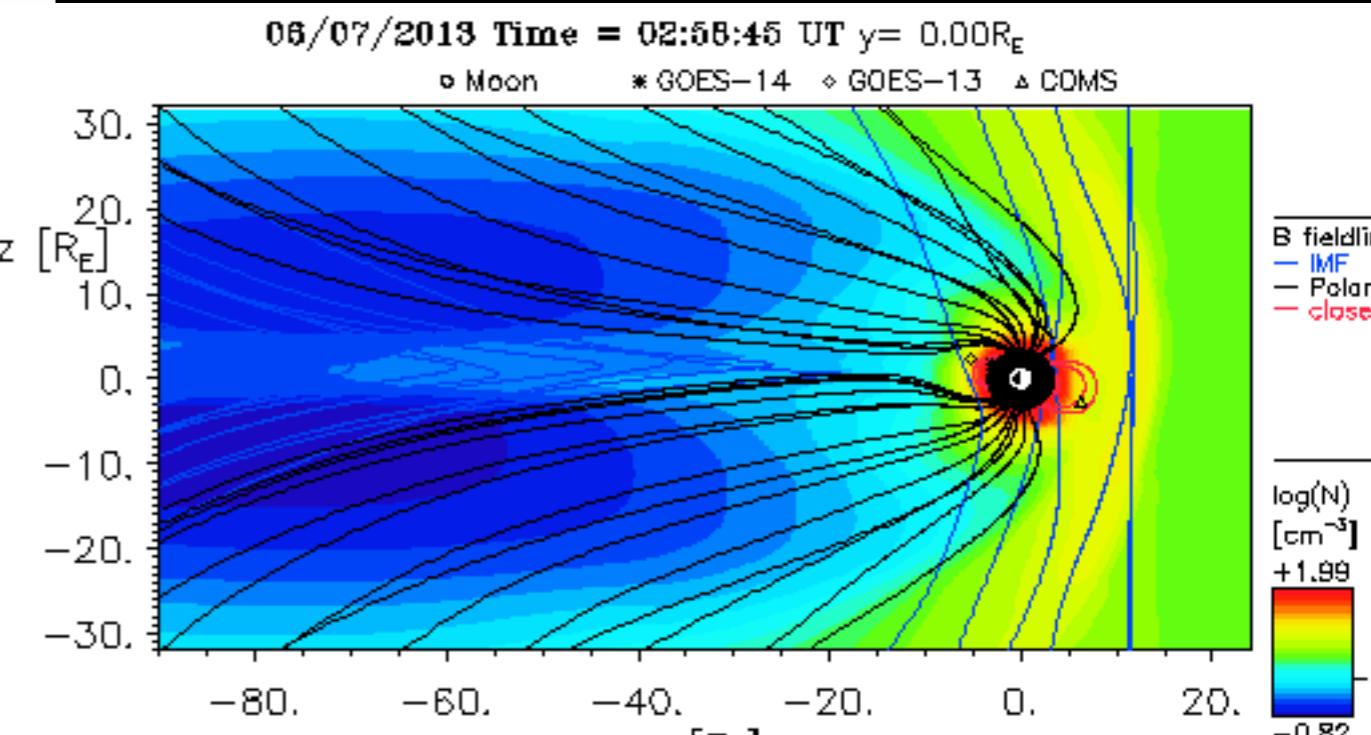
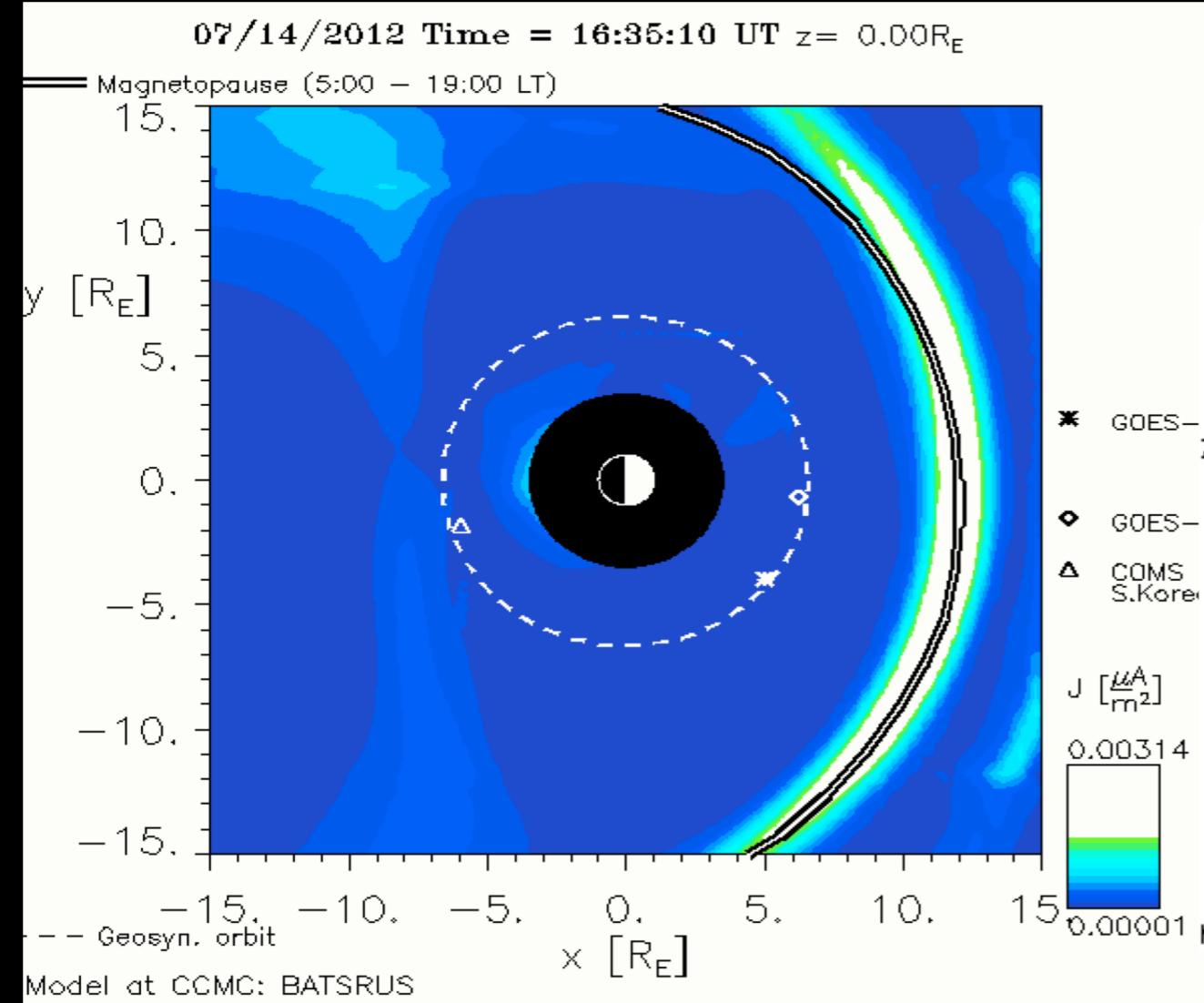


Space Weather Modeling Framework



The SWMF is freely available at <http://csem.engin.umich.edu>

SWMF

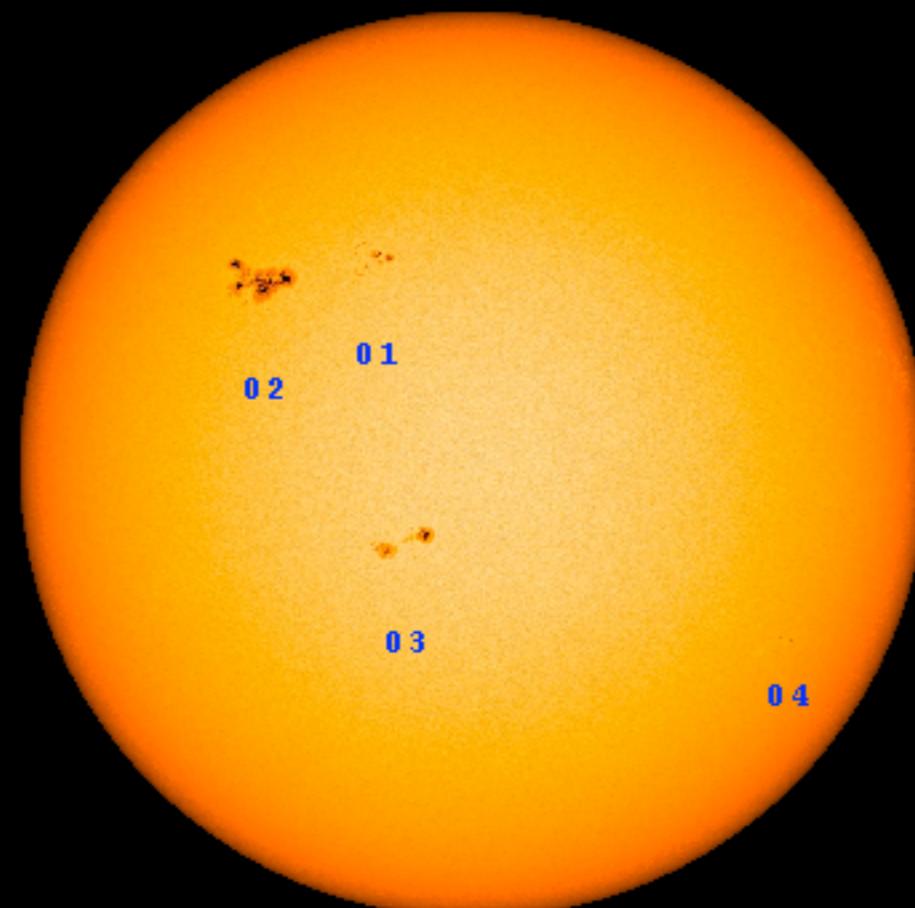


Flare Prediction Model

ASAP (Automatic Solar Activity Prediction)

<http://spaceweather.inf.brad.ac.uk/asap/>

SOLAR FLARE PROBABILITY = 52% 



NO	CLS	M	X
01	DAO	5%	1%
02	EKC	63%	66%
03	DAC	6%	4%
04	CSO	0%	0%

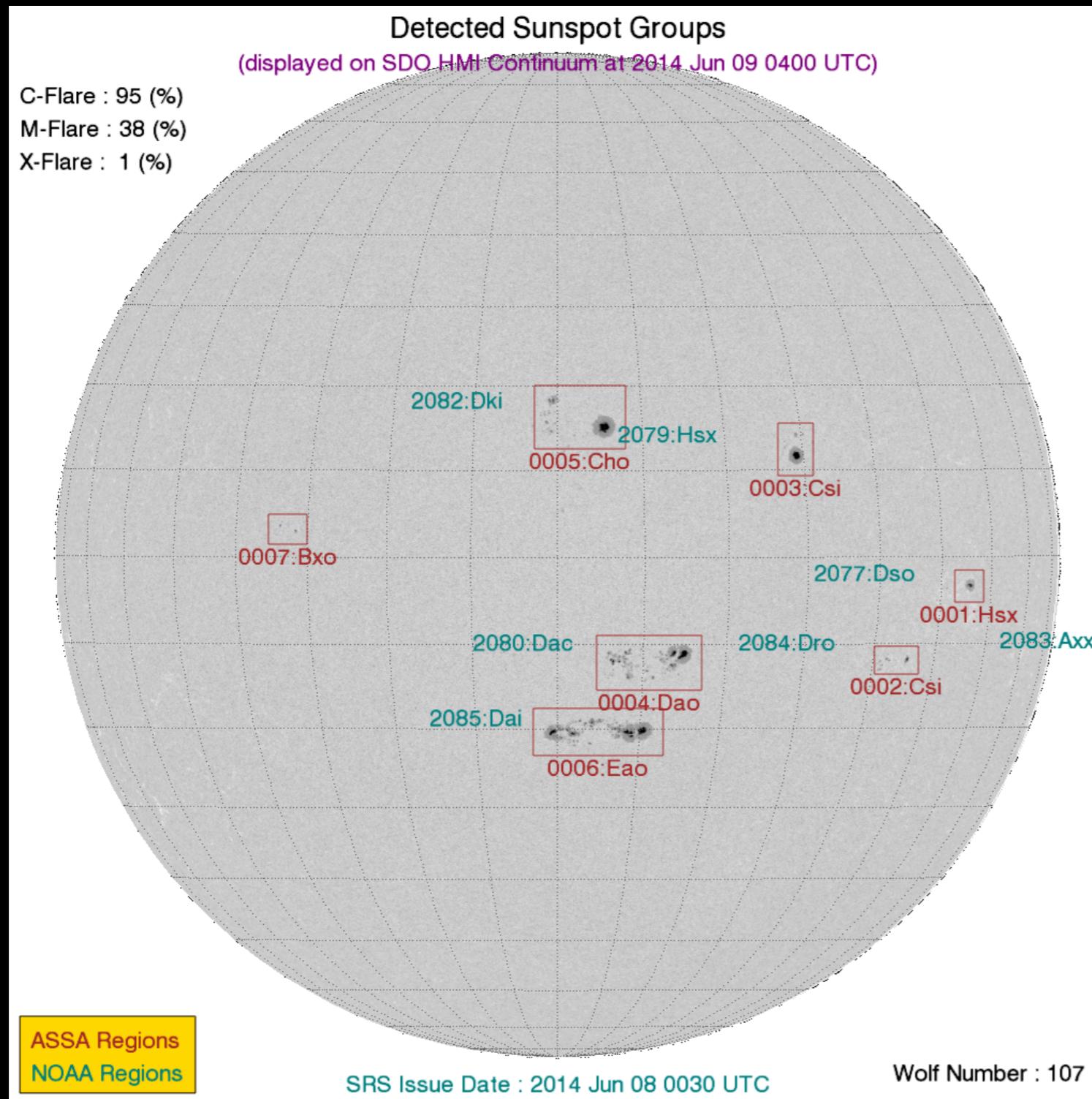
SOLAR FLARE MONITOR

Generated by ASAP
6/ 3/2012 23:45 UTC

<http://spaceweather.inf.brad.ac.uk/>
UNIVERSITY OF BRADFORD

Flare Prediction Model

ASSA (Automatic Solar Synoptic Analyzer)



Provided by

Korean Space Weather Center

Flare Prediction Model

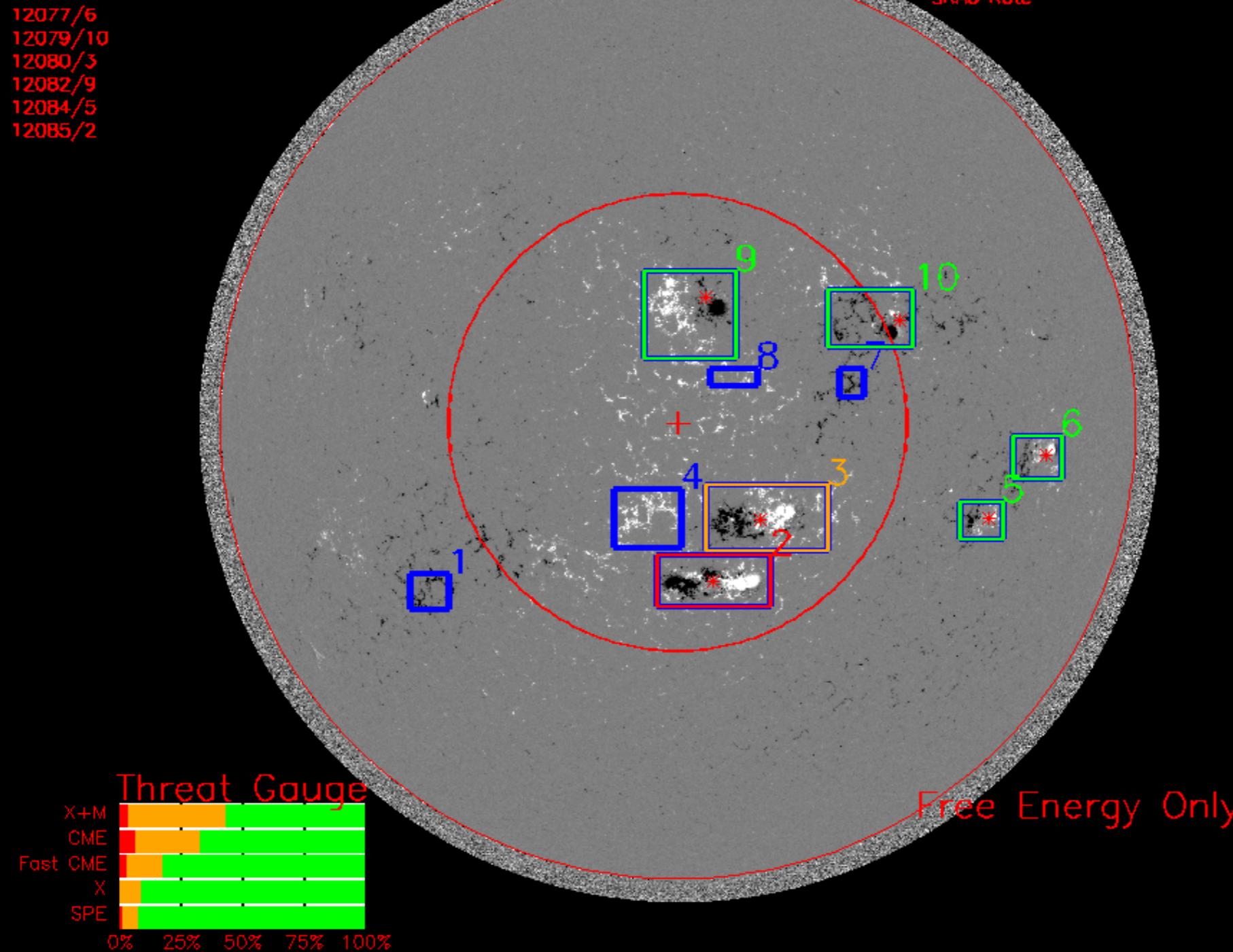
MAG4 (UAH/MSFC, Falconer et al.)

/usr/local/ccmc/MAG4_Distribution/mag4/DATA/HMI/hmi.M_45s_nrt.20140609_030045_TAI.2.magnetogram.fits(WEB)

NOAA ARs:

12077/6
12079/10
12080/3
12082/9
12084/5
12085/2

09-Jun-14 02:59
SRAC Rate



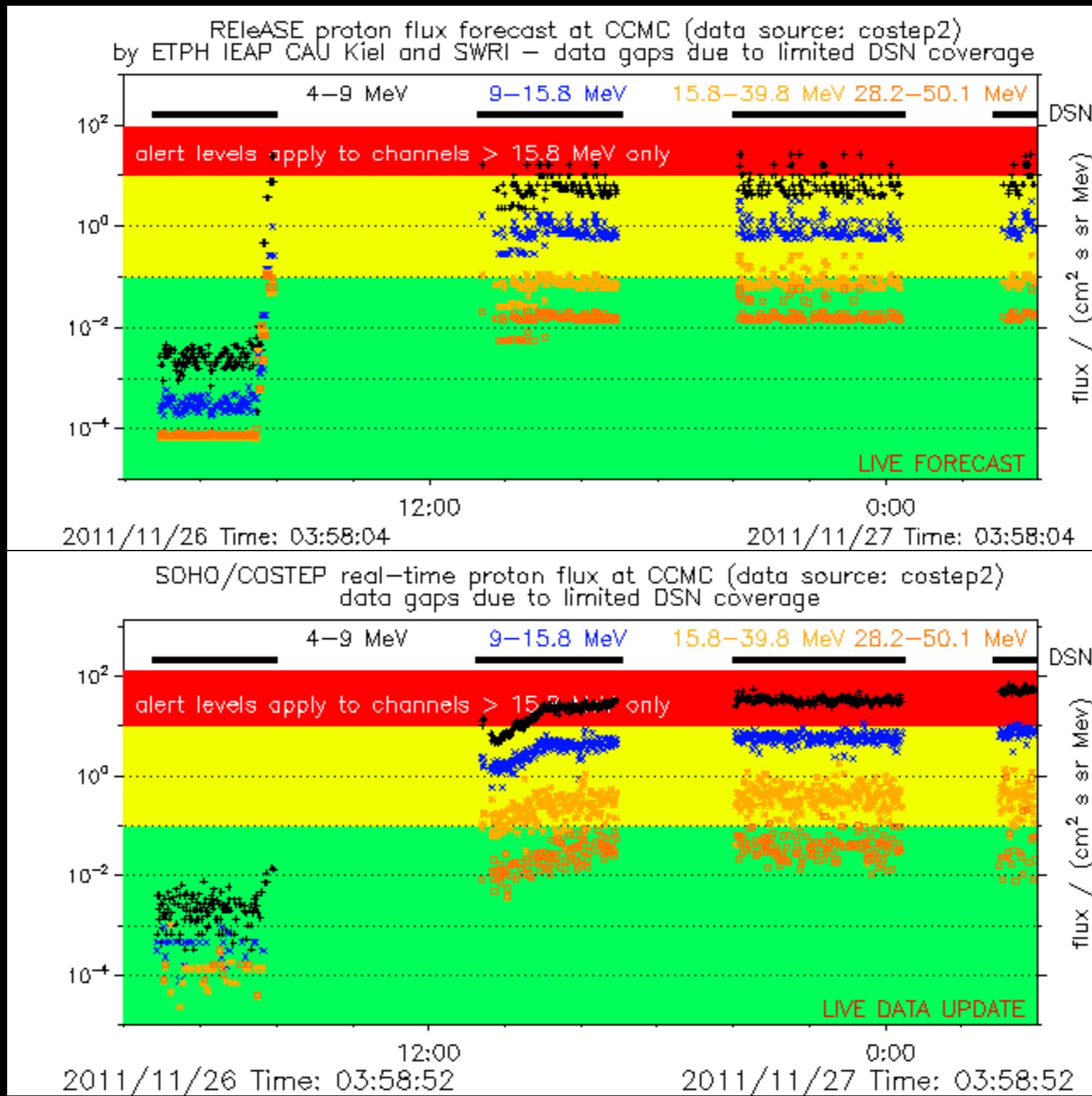
linux machine - Unregistered.user - code ddpro created at 08-Jun-2014 at time 04:02

SEP prediction

REleASE (Relativistic electron Alert System)

- Proton System for Exploration) based on electron measurements by SOHO/COSTEP
- developed by Arik Posner (NASA/HQ)
- Reference: Posner, A. (2007), Up to 1-hour forecasting of radiation hazards from solar energetic ion events with relativistic electrons, Space Weather, 5, S05001, doi:10.1029/2006SW000268.

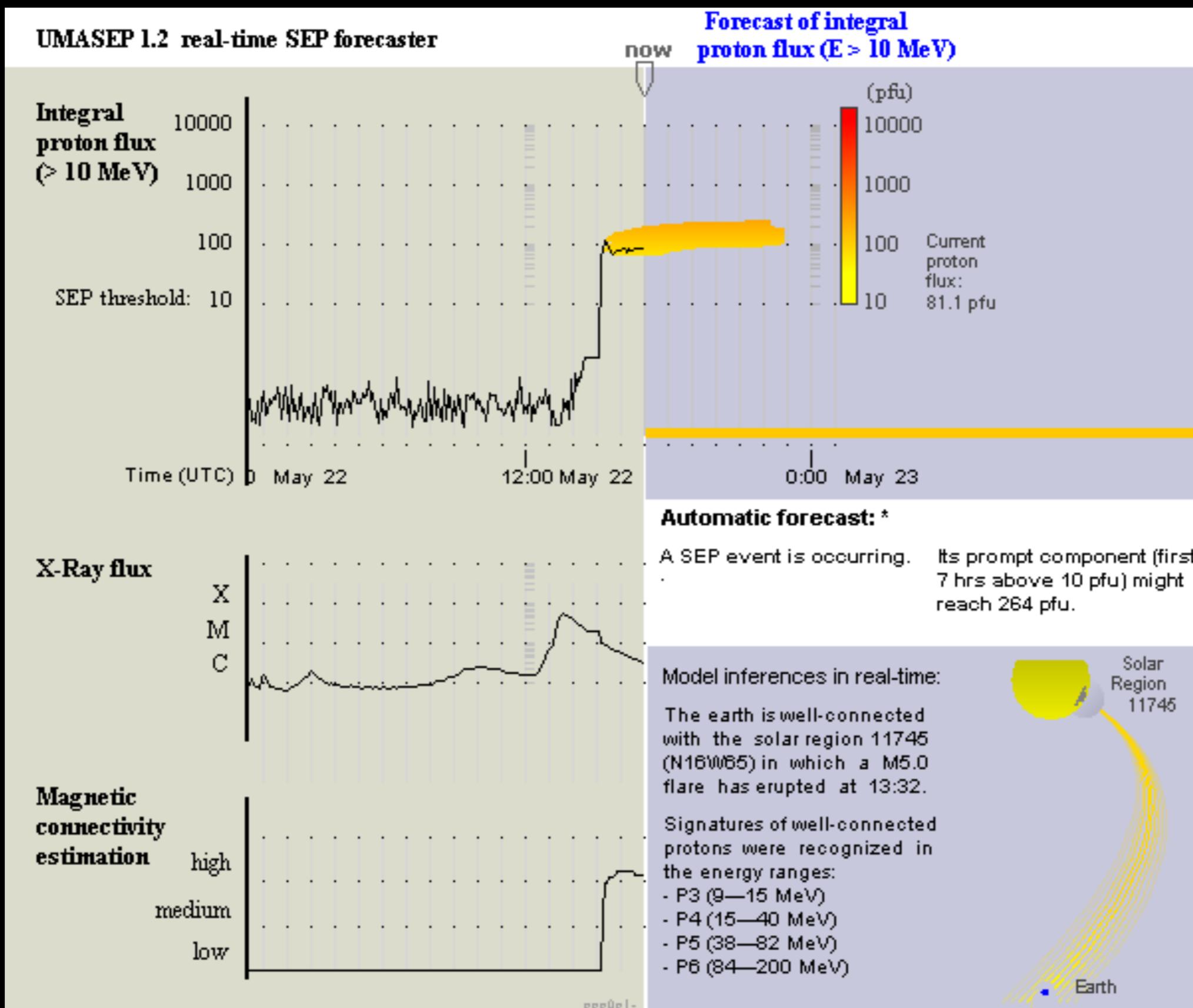
RELeASE: example



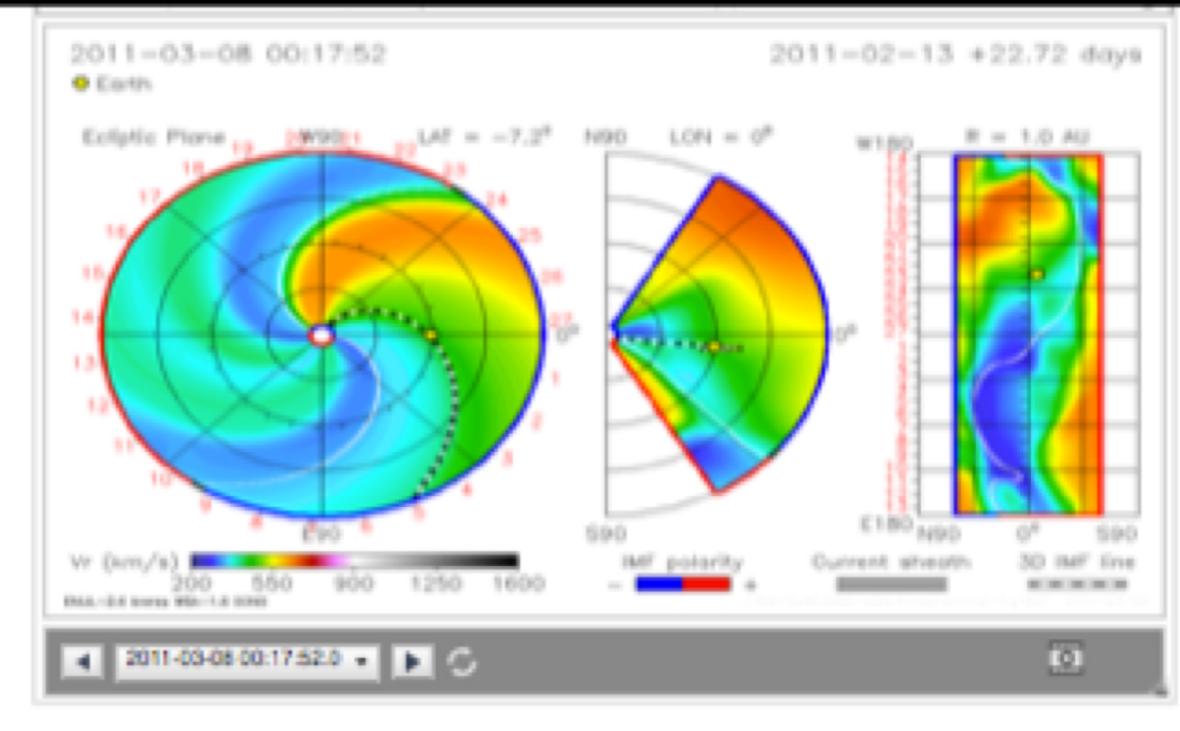
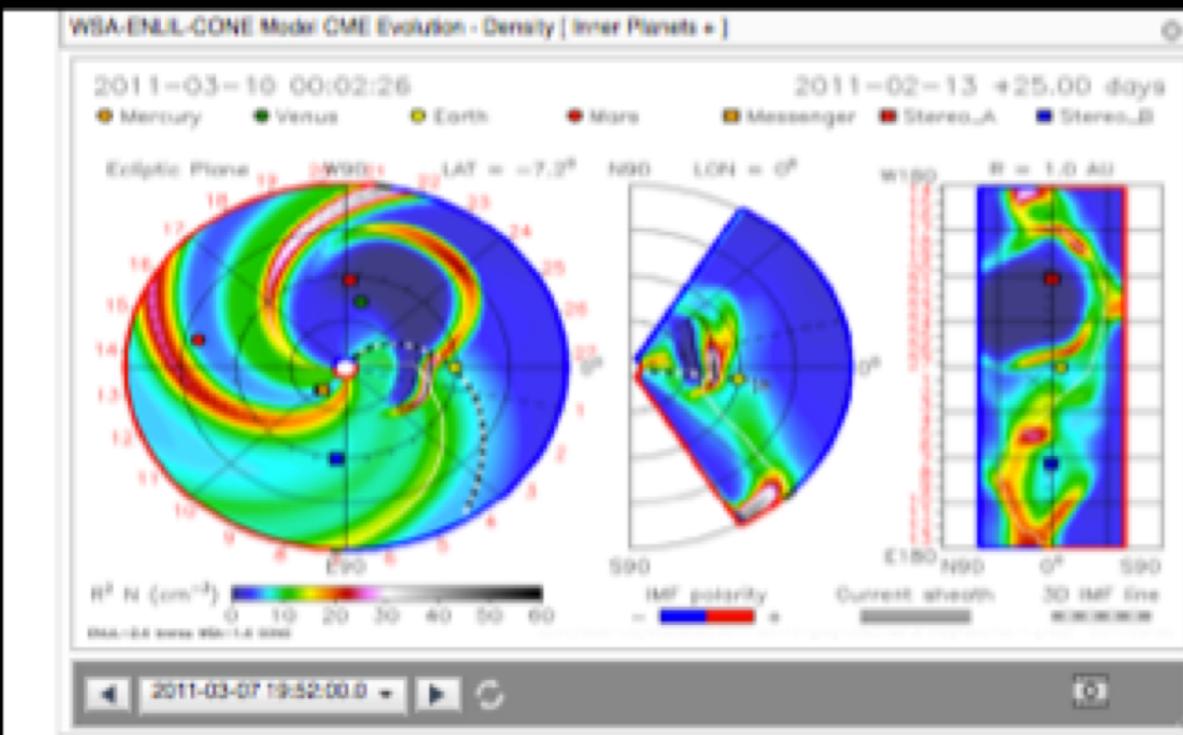
SEP prediction UMA proton flux forecast

- Núñez, M. (2011), Predicting solar energetic proton events ($E > 10 \text{ MeV}$), *Space Weather*, 9, S07003, doi 10.1029/2010SW000640.

UMASEP model



WSA+ENLIL

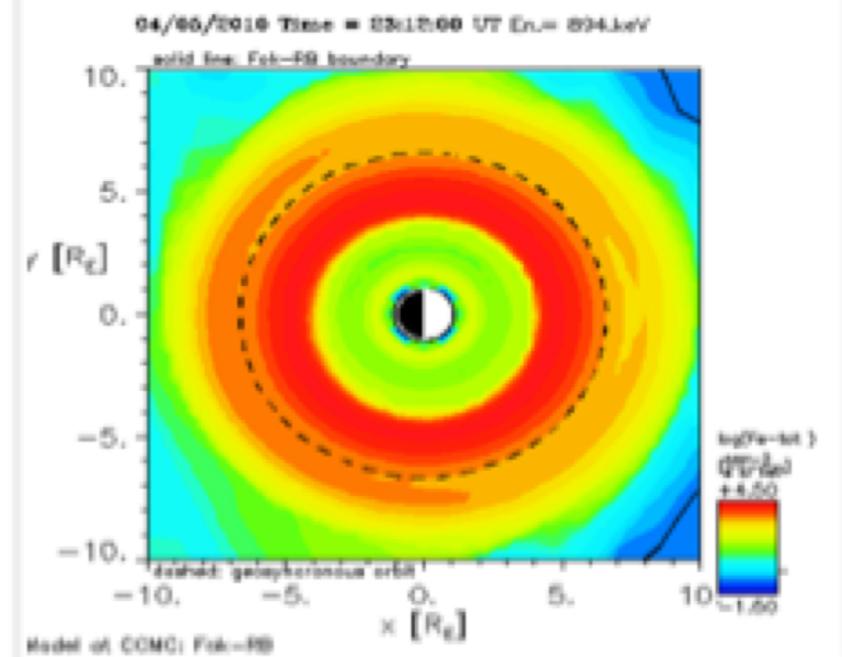
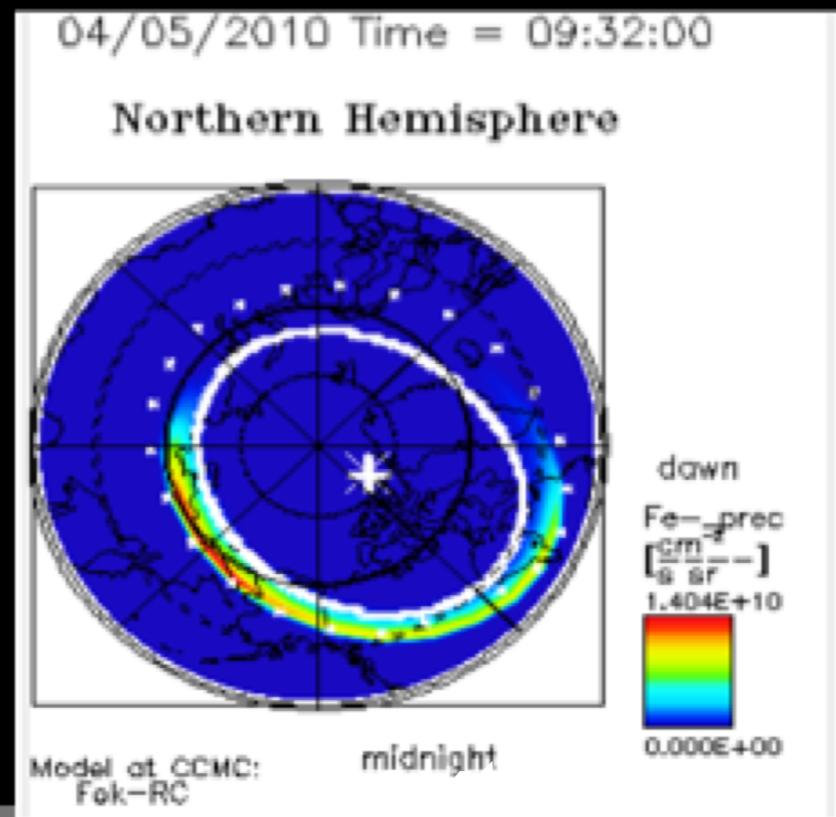
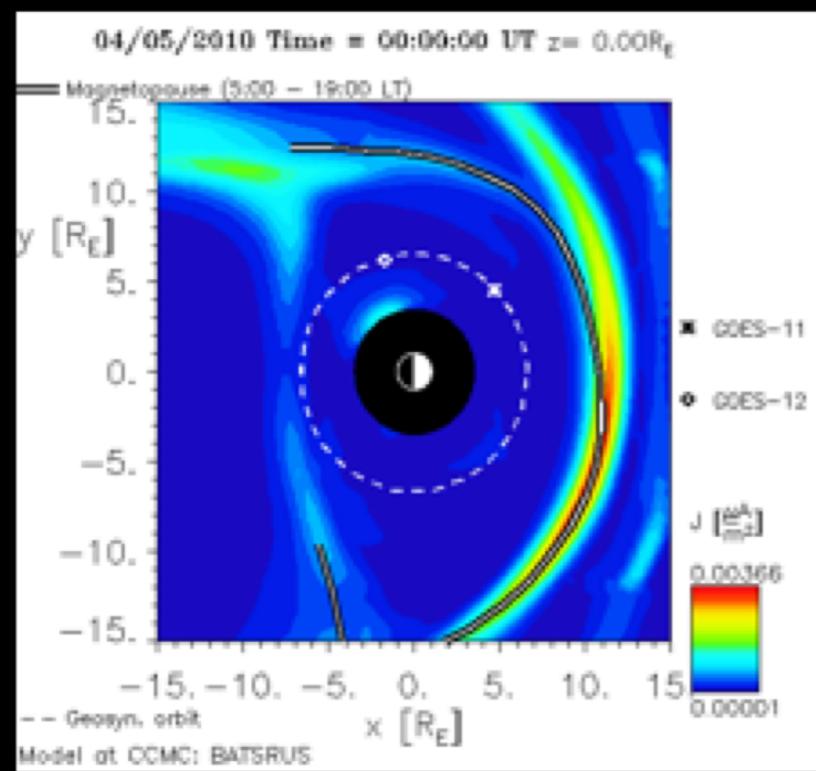


Predicting
transport/impacts of
CME

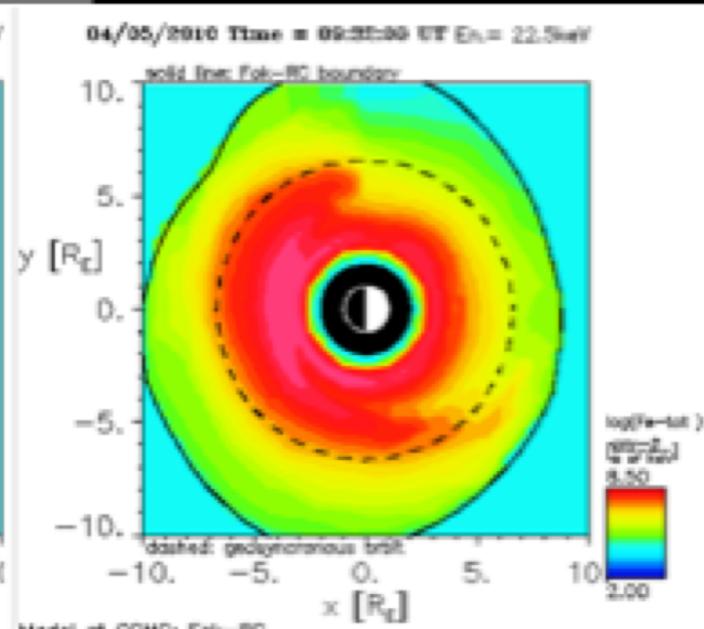
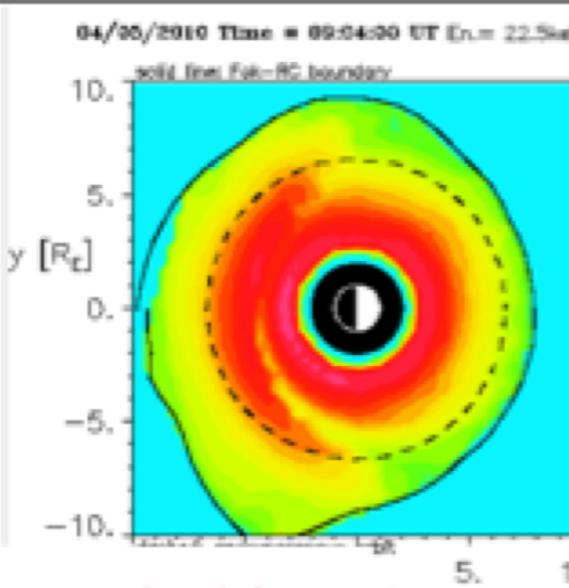
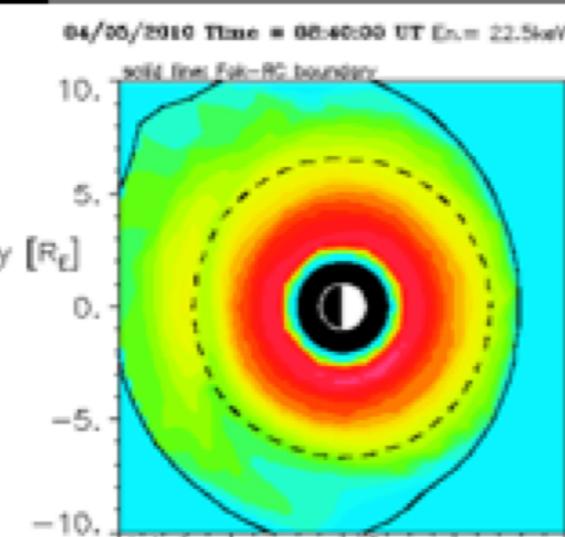
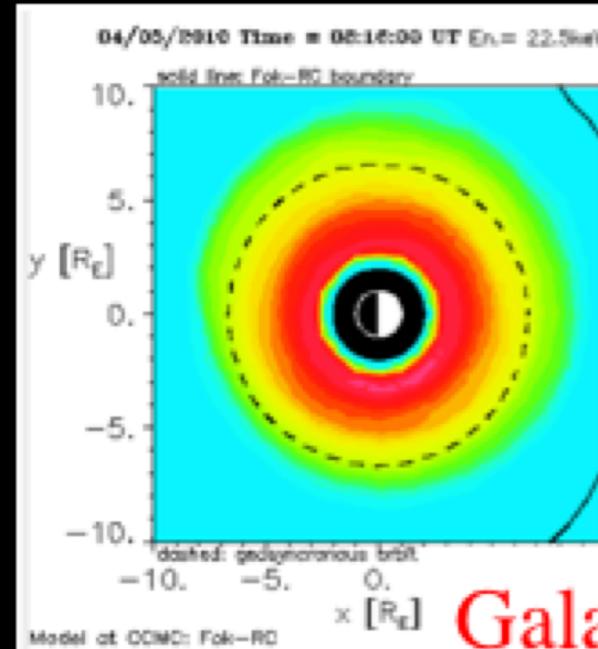
Modeling and
Predicting of the
ambient solar wind

primary and popular

Fok Ring Current Model

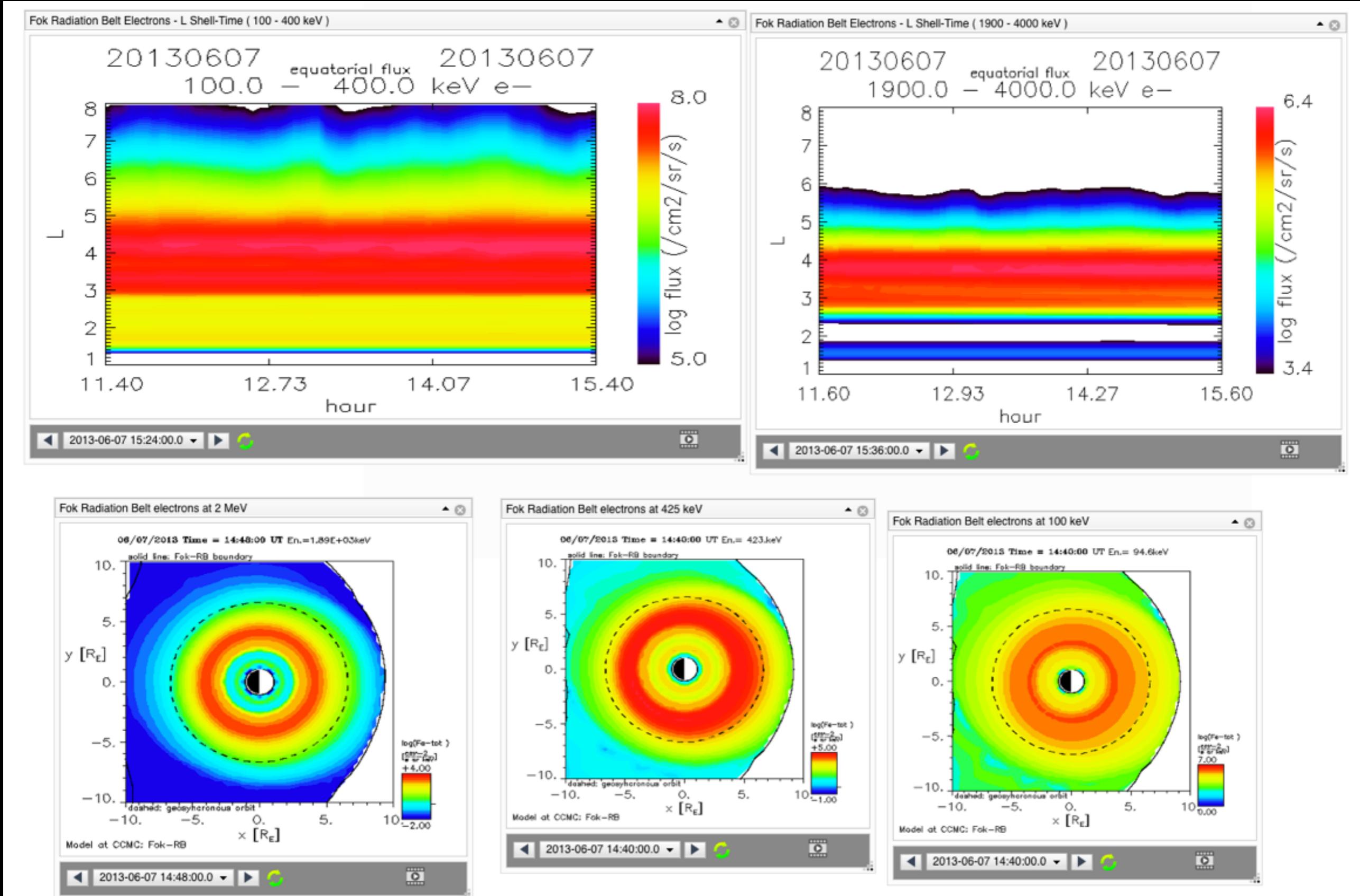


22keV electrons 4/5, 8:16-9:32Z



Galaxy 15 failed approx 9:48Z

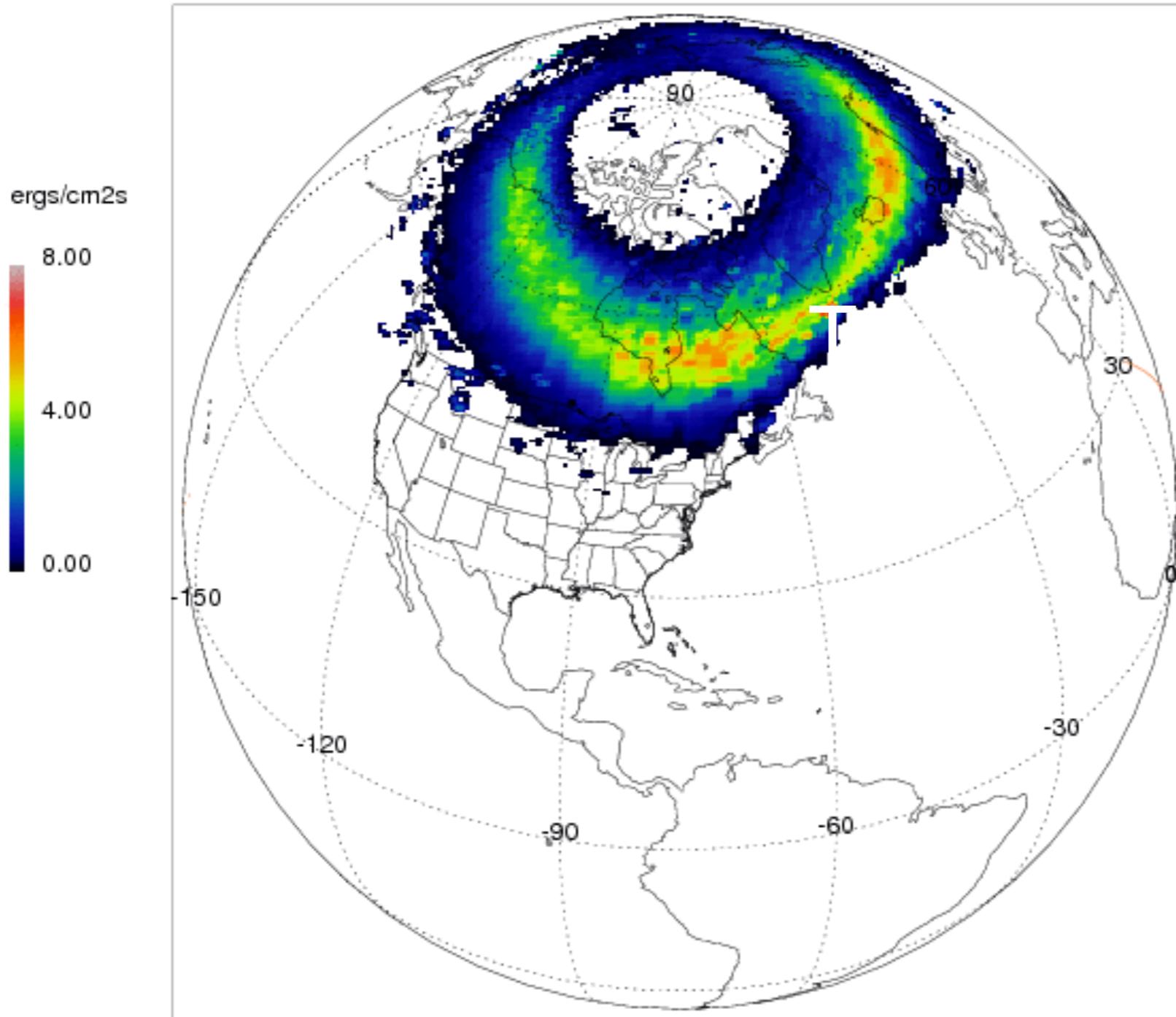
Fok Radiation Belt Model



Auroral Model Ovation Prime

all,e 2013/06/07 04:00:00 48.9 GW

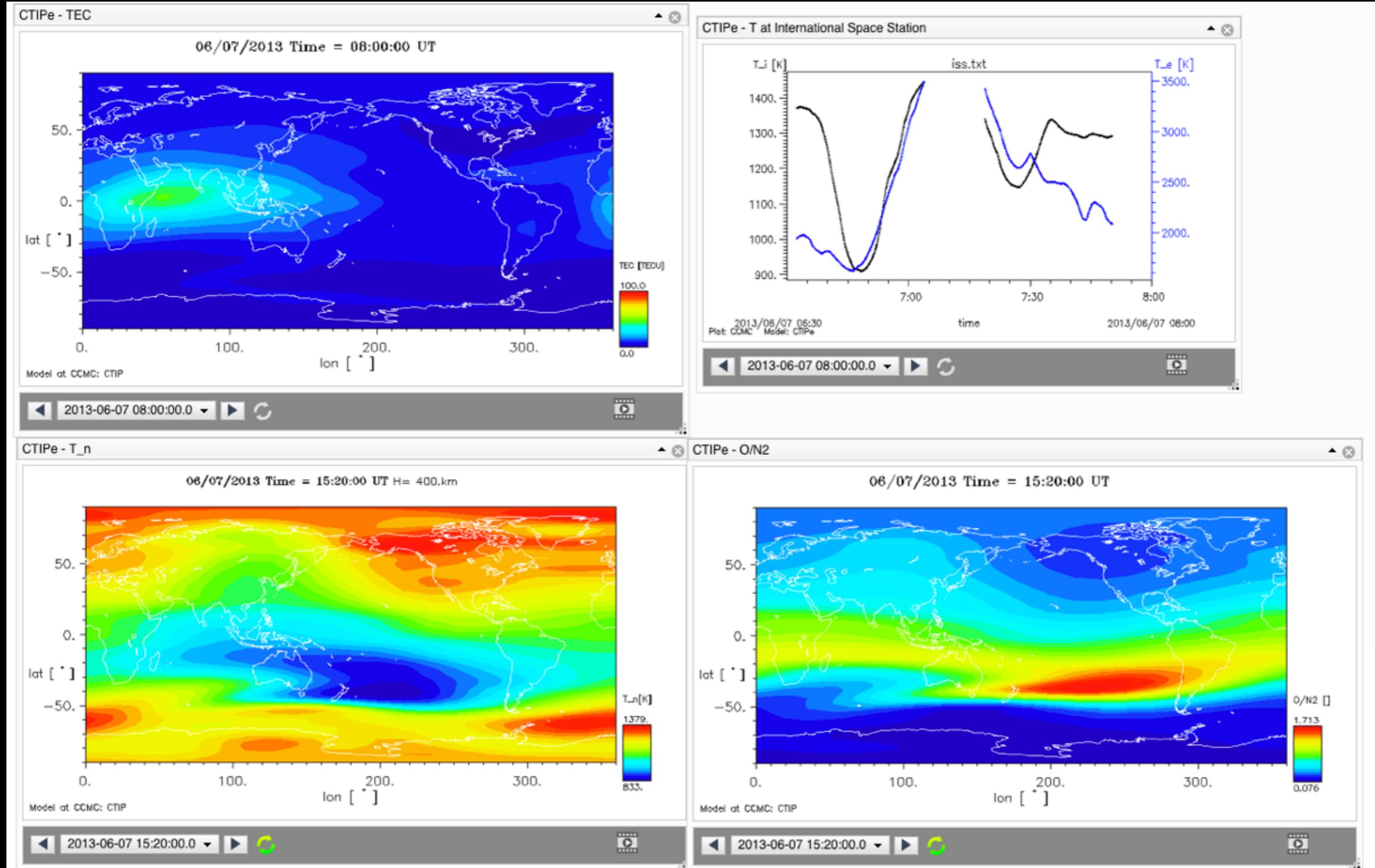
ISS



empirical model
based on ACE
measurements at
L1

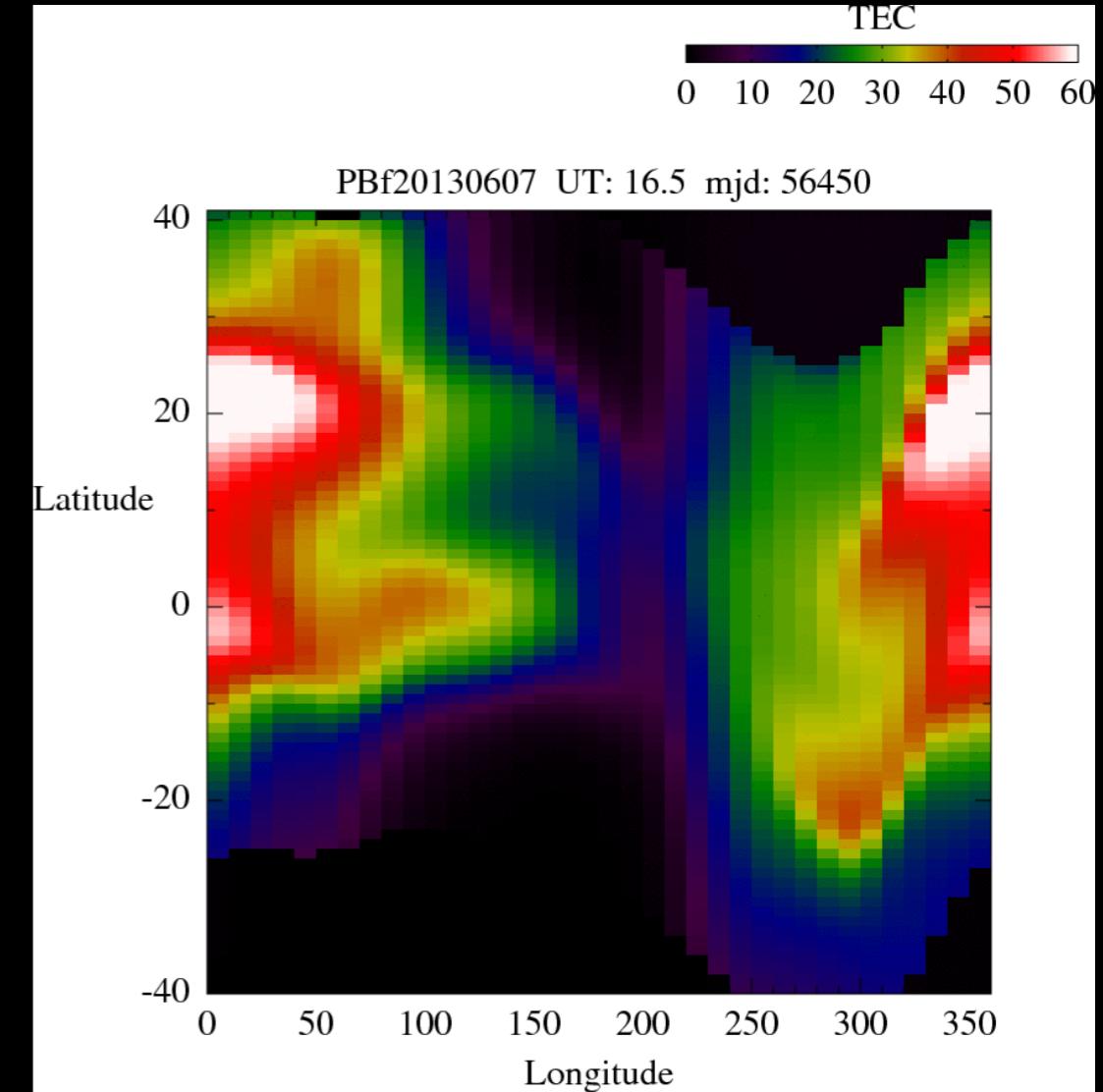
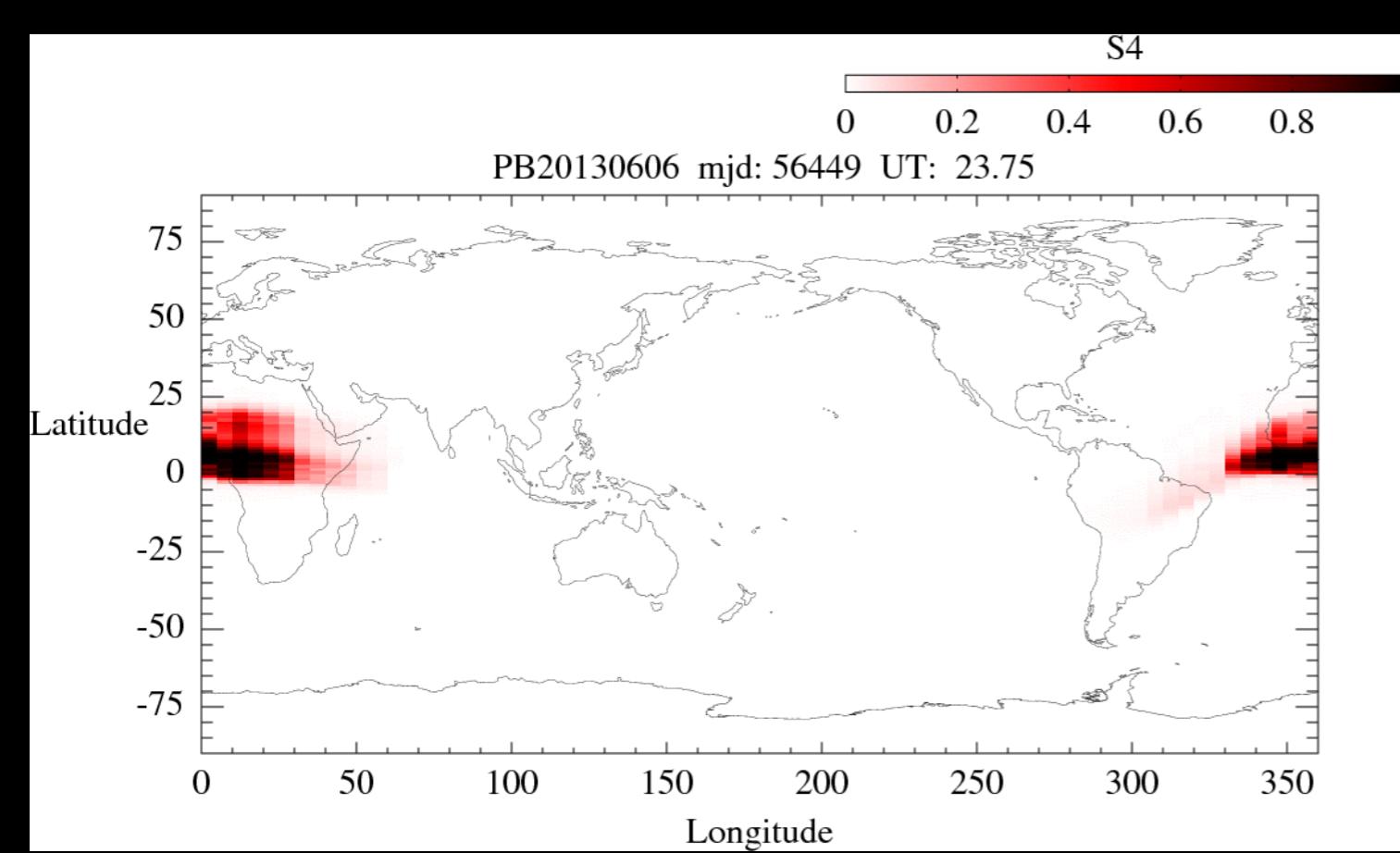
Newell et al., 2007, JGR

CTIe Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics Model



PBMOD scintillation model

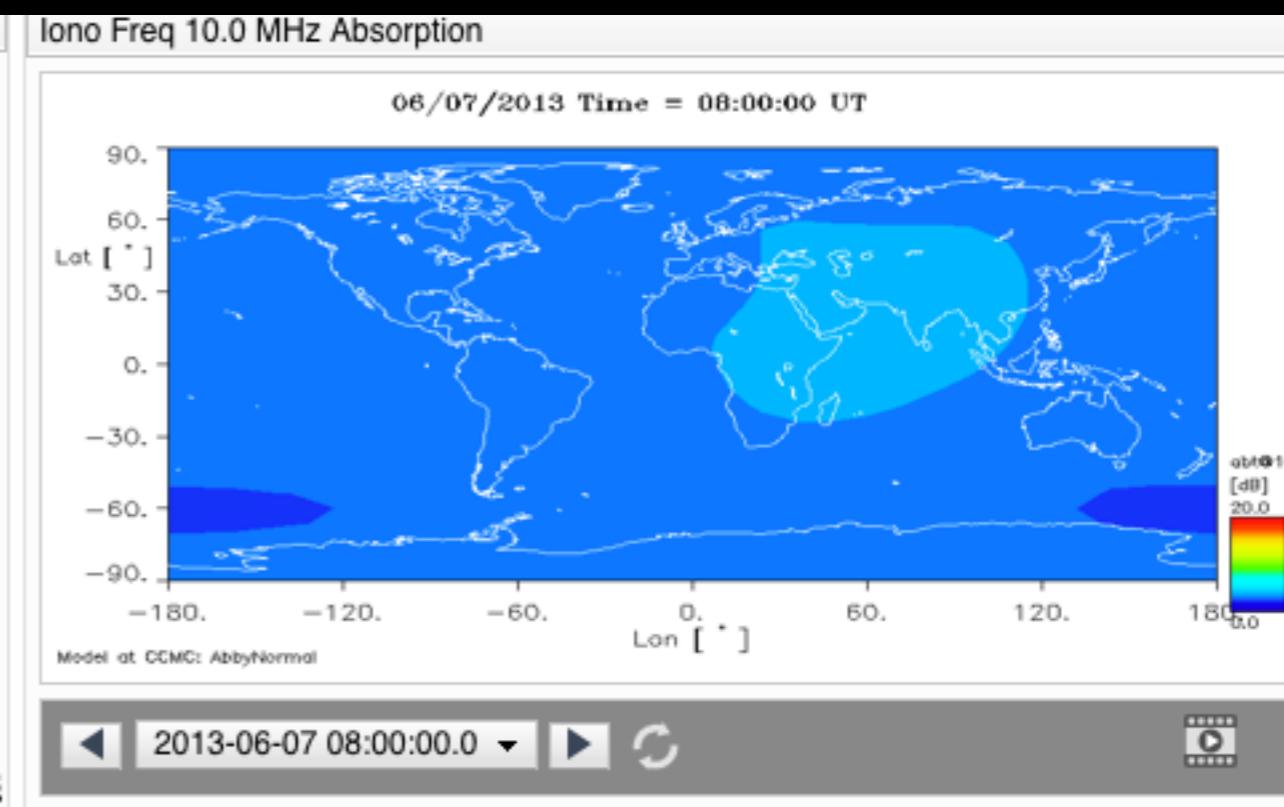
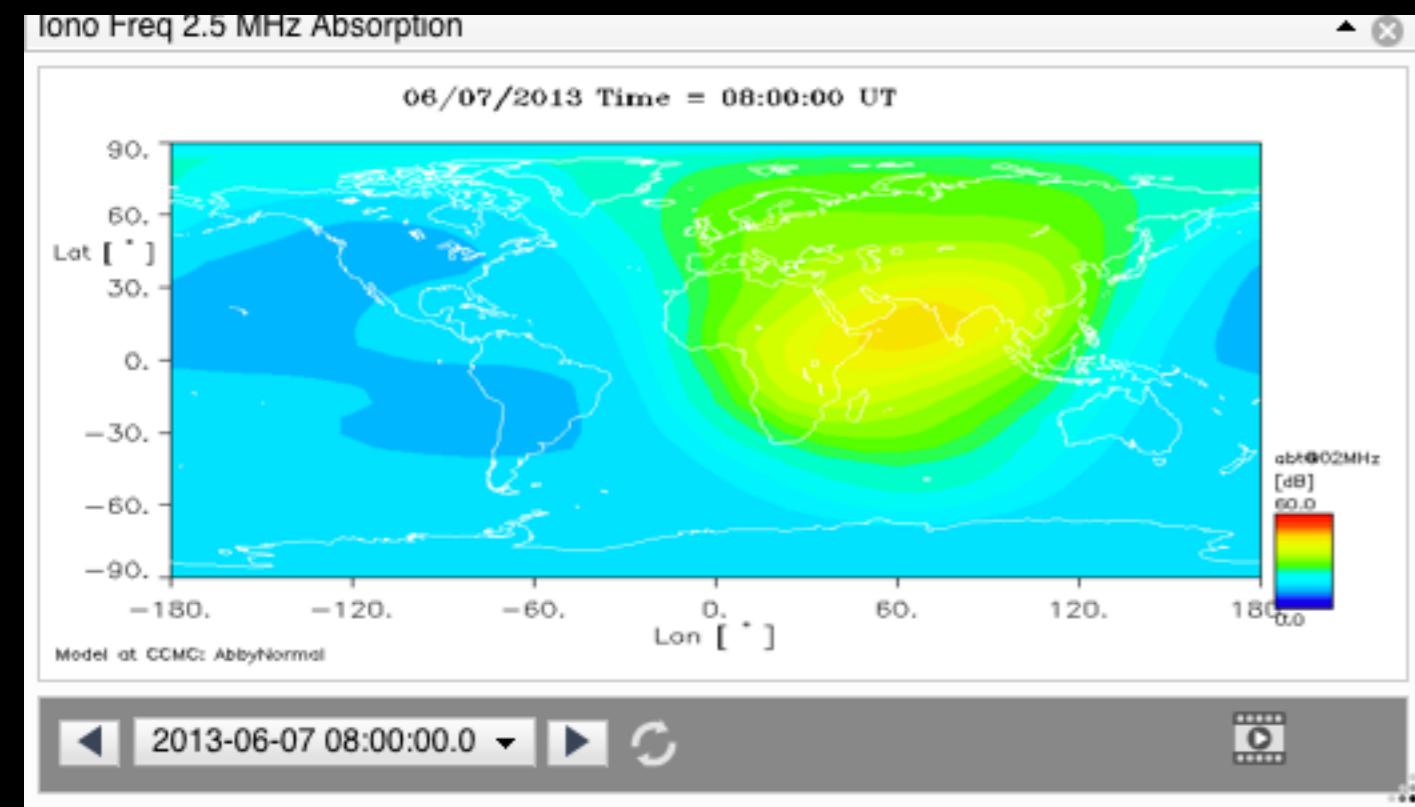
- http://ccmc.gsfc.nasa.gov/RoR_WWW/pbm od-rt/PBMOD-Text.html



ABBYNormal

HF signal absorption

- <http://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=ABBYNormal>



predicted K_p, D_{st}

- K_p based on Newell et al. formula
- D_{st} from SWMF
- D_{st} from WINDMI
- <http://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=WINDMI>